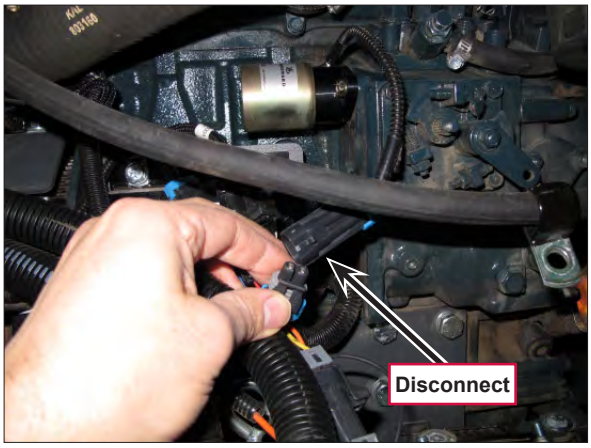
7. Disconnect the injector pump actuator connector to prevent the engine from starting.



8. Remove any cover over the air inlet but be very careful not to allow anything to get “sucked in” during the test.

9. Crank the engine over until the compression gauge stops climbing. Record the reading.

Specification is 541 to 597 psi (3.73 to 4.11 MPa) with an allowable limit of 327 psi (2.26 MPa). Difference among Cylinders - 10% or less.

10. Repeat for the other cylinders.

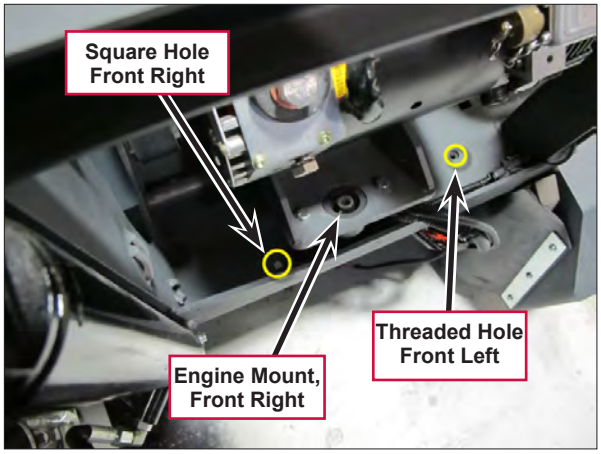
11. Reassemble in reverse order.

Removal and Installation

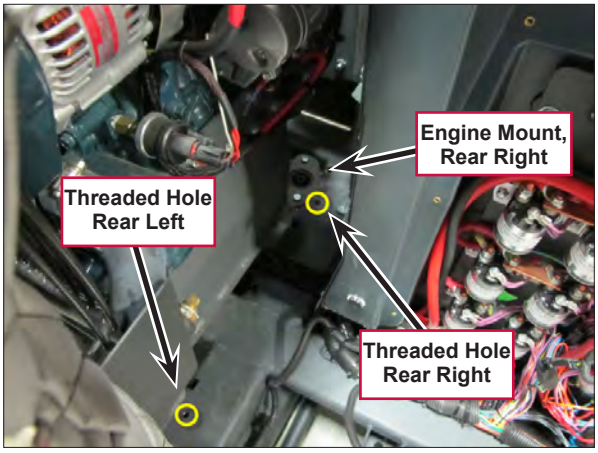
Engine Assembly

The complete engine including the exhaust, radiator and 42v alternator are removed as an assembly. There is no need to drain engine oil or coolant. The assembly is attached to the chassis at 4 rubber motor mounts. The front right mount has a square hole in the chassis for a carriage bolt. The other 3 are threaded holes in the frame.

1. Remove engine Top cover
2. Disconnect the 36v battery pack main positive and negative cables.
3. Disconnect the 12v battery negative cable.
4. Disconnect the 12v battery positive cable.
5. Disconnect fuel supply and return lines.
6. Disconnect battery positive and negative cables at the starter.
7. Disconnect the engine wiring connectors.
8. Remove the 4 motor mount fasteners.



Front engine mounting locations. Shown with hopper up and engine being installed.



Rear engine mounting locations. Shown with engine being installed.

9. Lift the assembly out of the chassis using a suitable hoist attached to the two engine lift points.
10. Reassemble in reverse order. Connect the battery negative cables last.

Specifications

Fuel Pump;

- Fuel Pressure 2.5 - 4 PSI
- Fuel Volume - 0.5 Gallons per minute

Glow Plugs

- Resistance - Approx. 0.9 ohms
- Current Draw - Approx. 12 - 13 Amps. (As the glow plugs heat up, resistance increases and current decreases)

Engine Compression

541 to 597 psi (3.73 to 4.11 MPa) with an allowable limit of 327 psi (2.26 MPa). Difference among Cylinders - 10% or less.

Engine Oil Capacity

1.5 US Gallons (5.7L)

Engine Oil Type

Refer to the following table for the suitable American Petroleum Institute (API) classification of engine oil according to the engine type (with internal EGR, external EGR or non-EGR) and the Fuel Type Used : (Low Sulfur, Ultra Low Sulfur or High Sulfur Fuels).

Fuel Type	Engine oil classification (API classification)	
	Engines with non-EGR Engines with internal EGR	Engines with external EGR
High Sulfur Fuel [0.05 % (500 ppm) ≤ Sulfur Content < 0.50 % (5000 ppm)]	CF (If the “CF-4, CG-4, CH-4, or CI-4” engine oil is used with a high-sulfur fuel, change the engine oil at shorter intervals.(approximately half))	
Low Sulfur Fuel [Sulfur Content < 0.05 % (500 ppm)] or Ultra Low Sulfur Fuel [Sulfur Content < 0.0015 % (15 ppm)]	CF, CF-4, CG-4, CH-4 or CI-4	CF or CI-4 (Class CF-4, CG-4 and CH-4 engine oils cannot be used on EGR type engines.)

- CJ-4 classification oil is intended for use in engines equipped with DPF (Diesel Particulate Filter) and is Not Recommended for use in Kubota E3 specification engines.

- Oil used in the engine should have API classification and Proper SAE Engine Oil Viscosity according to the ambient temperatures where the engine is operated.
- With strict emission control regulations now in effect, the CF-4 and CG-4 engine oils have been developed for use with low sulfur fuels, for On-Highway vehicle engines. When a Non-Road engine runs on high sulfur fuel, it is advisable to use a “CF or better” classification engine oil with a high Total Base Number (a minimum TBN of 10 is recommended).

Engine Oil Viscosity

Temperature	Viscosity
Above 25 °C (77 °F)	SAE 30 or SAE 10W-30 SAE 10W-40
0 °C to 25 °C (32 °F to 77 °F)	SAE 20 or SAE 10W-30 SAE 10W-40
Below 0 °C (32 °F)	SAE 10W or SAE 10W-30 SAE 10W-40

Cooling System

Engine Coolant

A 50/50 mix of distilled water and ethylene glycol is recommended.

Radiator Cap

13 PSI

Shop Measurements

The following information provides some “real world” shop measurements to help you recognize what “normal” looks like.

Engine RPM Sensor

Resistance: 2.2K ohms

Output while cranking (Unplugged) - 3.0 - 5.0 VAC

Output at idle (Connected) - 10.8 VAC

Actuator

Resistance: 3.0 Ohms

Engine Compression

#1 = 410 psi

#2 = 420 psi

#3 = 400

Fuel System Return Fuel Flow

4.0 oz (120 ml) with the return line removed, engine off and fuel pump running

Starter

168 Amps cranking

Glow Plug Relay

Winding 46 Ohms

Special Tools

Diesel Compression Gauge There are many brands of compression gauges available. Shown is a Snap-On EEPD500 Gauge kit	
Compression Gauge Fitting for Glow Plug threads. Shown is Snap-On TU-15-35 Threads - M8 X 1.0	
Gauge Coupler If using the Snap-On diesel compression EEPD500 Gauge kit and Snap-On TU-15-35 glow plug thread fitting, a coupler must be used to join the fitting to the gauge hose. Shown are Snap-On couplers M3569 and M3570	

Engine System - LPG

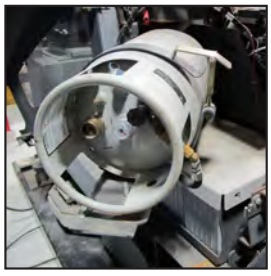
This chapter covers the things “on top” of the mechanical engine that make it run, such as the fuel system, governor control and ignition system. It also includes routine engine maintenance information and troubleshooting of engine starting or running problems. See the Kubota WG972 E3 Workshop Manual 9Y111-05710 for detailed information related to the complete mechanical engine.

Functional Description

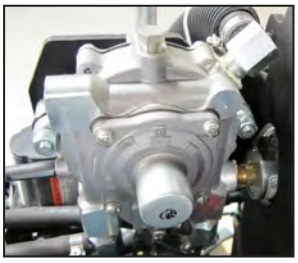
One of the engines available in the CS7000 is a LPG Kubota (WG972-GL-E3-NFK-1). It is a three cylinder, liquid cooled, naturally aspirated engine. The fuel system does not utilize a control module. It is mechanically controlled. The ignition system is “self-contained”. That is, it has no interaction with the fuel system and shares no components with it.

The fuel system begins with a 33 pound propane fuel tank which is horizontally mounted on the right side of the engine compartment. The tank swings out to provide easier access to the engine compartment. There is an in-line pressure relief valve and a pressure switch between the tank and the fuel pressure vaporizer/regulator. The fuel pressure vaporizer/regulator takes in high-pressure propane liquid, changes it to a vapor and reduces it to a constant low pressure gas for the engine to draw in and burn. The change from liquid to gas absorbs a lot of heat and acts as an air conditioner. To prevent frosting up the regulator, it is heated with engine coolant. The vaporizer/regulator supplies gaseous fuel to the carburetor through a hose. The carburetor has an additional fuel shut off solenoid that must be energized for fuel to flow through the carburetor to the engine.

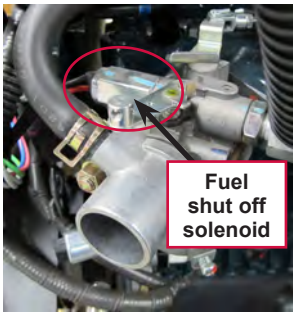
Kubota LPG Engine



Propane Fuel Tank



Fuel Vaporizer/ Regulator



Carburetor

The engine RPM is controlled with a Woodward L-Series governor/speed actuator based on requests from the main machine controller. The main machine controller sends signals to the Woodward L-Series governor/speed actuator to request one of three engine speeds based on operator request or cleaning mode. The actuator has a “built in” microprocessor which receives the requests and in turn physically moves the carburetor/mixer throttle blade to achieve the requested engine speed.

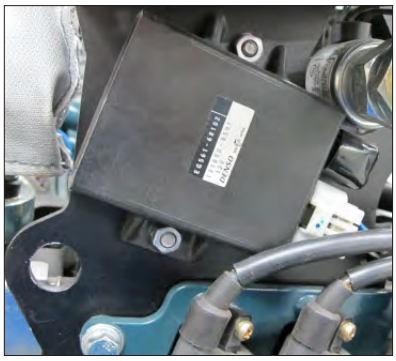
The cooling system consists of a standard radiator and belt driven fan. Note that the fan pushes air away from the engine and out through the radiator.

Woodward L Series Actuator

Circuit Descriptions

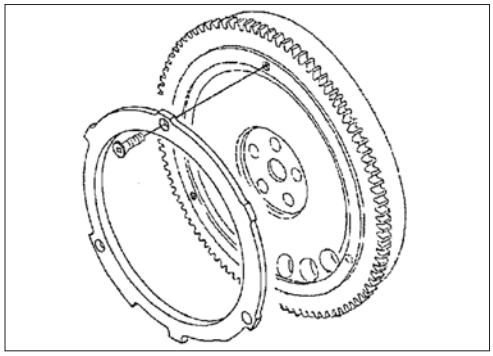
Ignition System

The ignition system consists of a spark control module (aka Ignitor), three ignition coils, and a crank position sensor. The crank position sensor reads a rotating 6 toothed ring which is mounted on the flywheel between the flywheel and the engine.

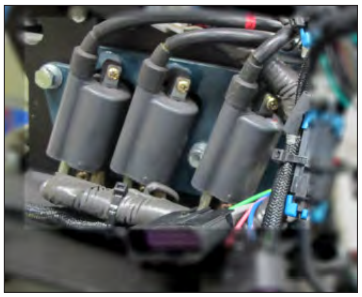


Spark Control module

Crank Position Sensor



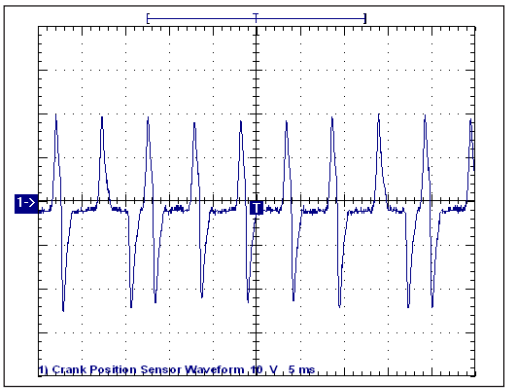
Toothed Ring and flywheel



Ignition Coils

The heart of the system is the spark control module. It controls the current flow of each ignition coil primary circuit in order to control when spark occurs based on inputs from the crank position sensor. Each coil fires twice per cylinder cycle. Once to initiate the power stroke and once in exhaust stroke (waste spark)

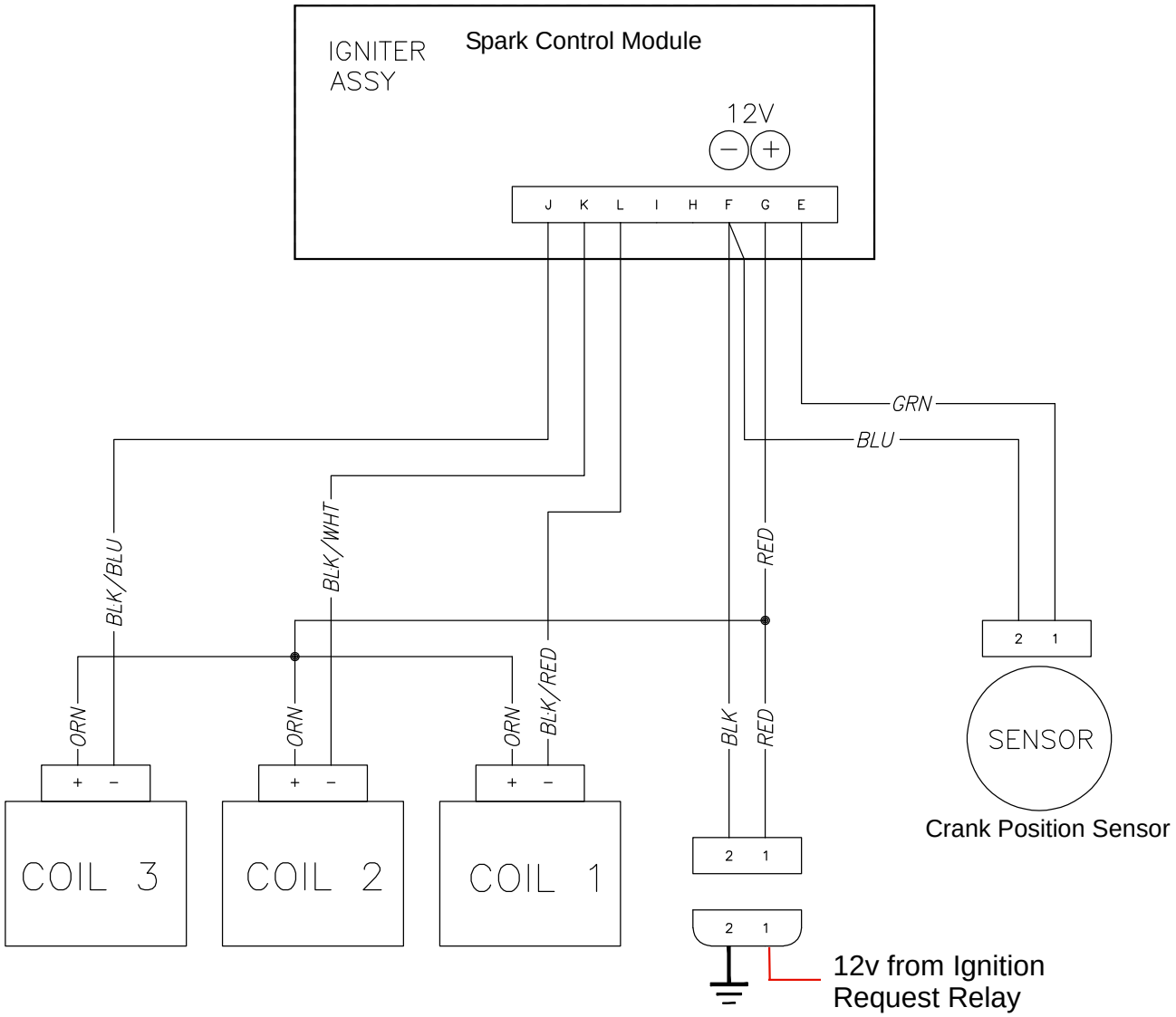
The crank sensor is a two wire " AC pulse generator". It has a wire coil inside of it. As the toothed ring rotates, the teeth pass in line with the end of the sensor tip. This induces a voltage spike that the spark control module can "read" as cylinder position information. The number of spikes per minute is translated as engine RPM. One tooth on the ring is wider than the other five. This creates a unique "spike" so that the spark control module can distinguish the cylinders from one another. This allows it to fire the right ignition coil at the right time. Below is what the crank sensor wave form looks like on an oscilloscope. Notice that every sixth pattern is "wide".



The spark control module is fed power on pin G from the Ignition Request relay. Pin F is connected to ground.

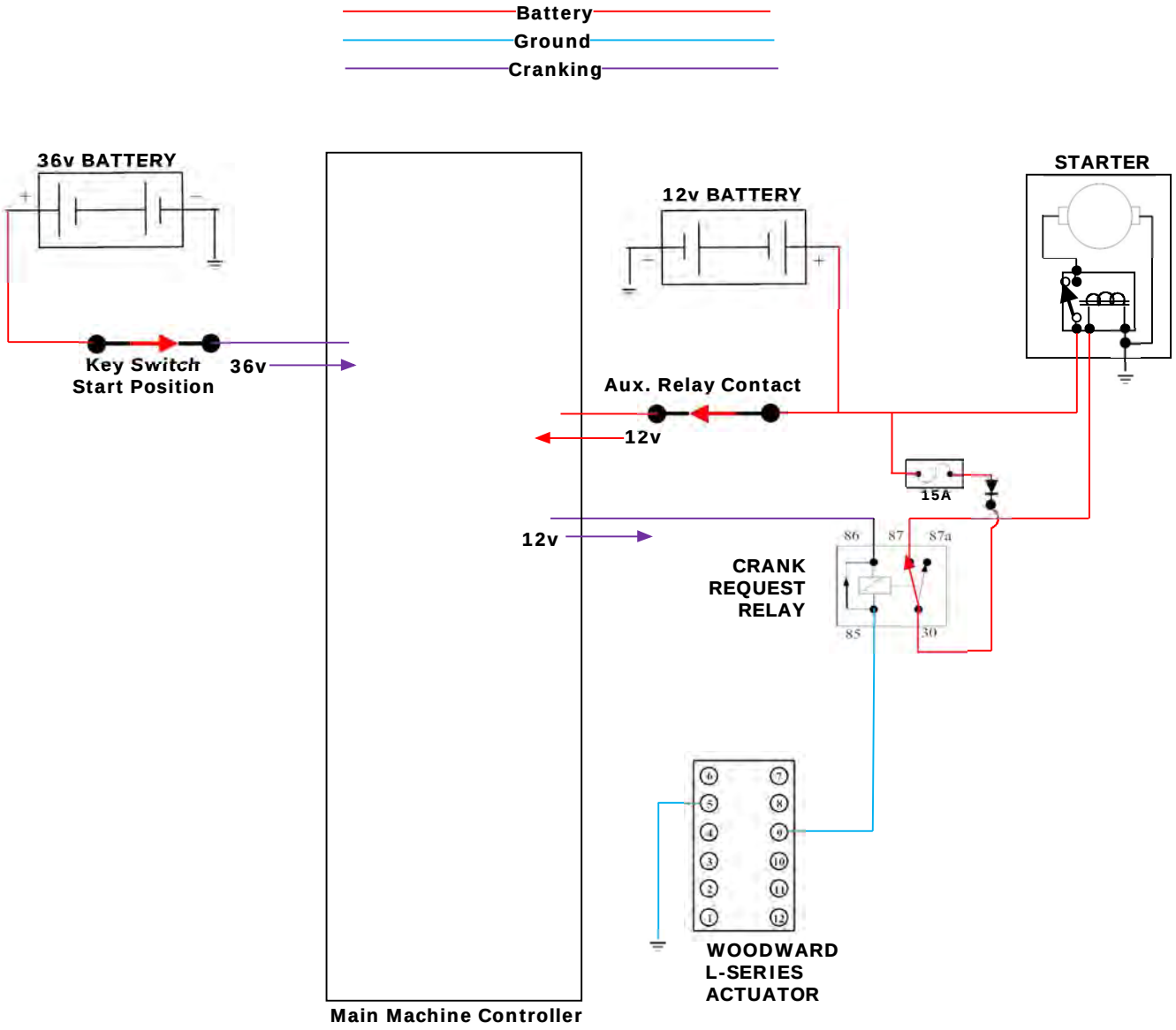
The two wires form the crank position sensor are connected to pins E and F.

All three ignition coils are fed the same power from the ignition request relay. The 12v power supply flows through each coil primary circuit to the spark control unit. The spark control unit supplies a “switched ground” for each of the ignition coil primary windings. When it supplies a ground, current flows through the coil primary winding and builds up a magnetic field around the coil. When the ground is released, the current stops flowing abruptly and the magnetic field collapses. The collapsing magnetic field induces a high voltage in the ignition coil secondary winding which produces a spark across the gap of the spark plug and ignites the air fuel mixture.



Engine Starter Control

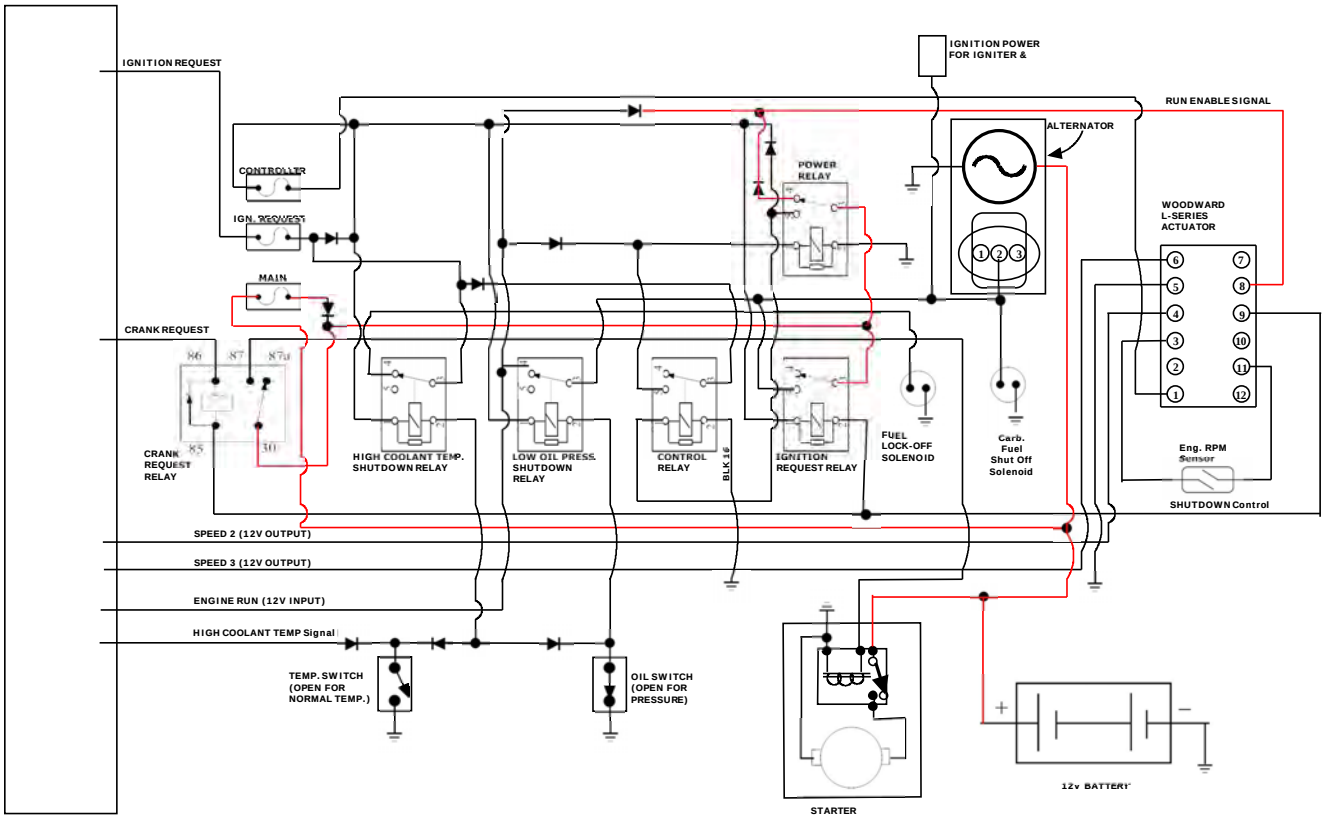
To get the engine starter to engage, the key switch is held in the start position which supplies 36 volts to the main machine controller on the violet wire with the green stripe to connector J7 pin 19. This is the start input request. The main machine controller receives a 12 V supply on connector J3 pin 23 from the engine starter battery. It uses this voltage supply to send 12 volts out of connector J3 pin 10 to the crank request relay coil. The other side of the relay coil is grounded through the Woodward L-series actuator. With power and ground across the relay winding the relay energizes and fused battery power from terminal 30 is sent to the starter solenoid.



Throttle Control Modes

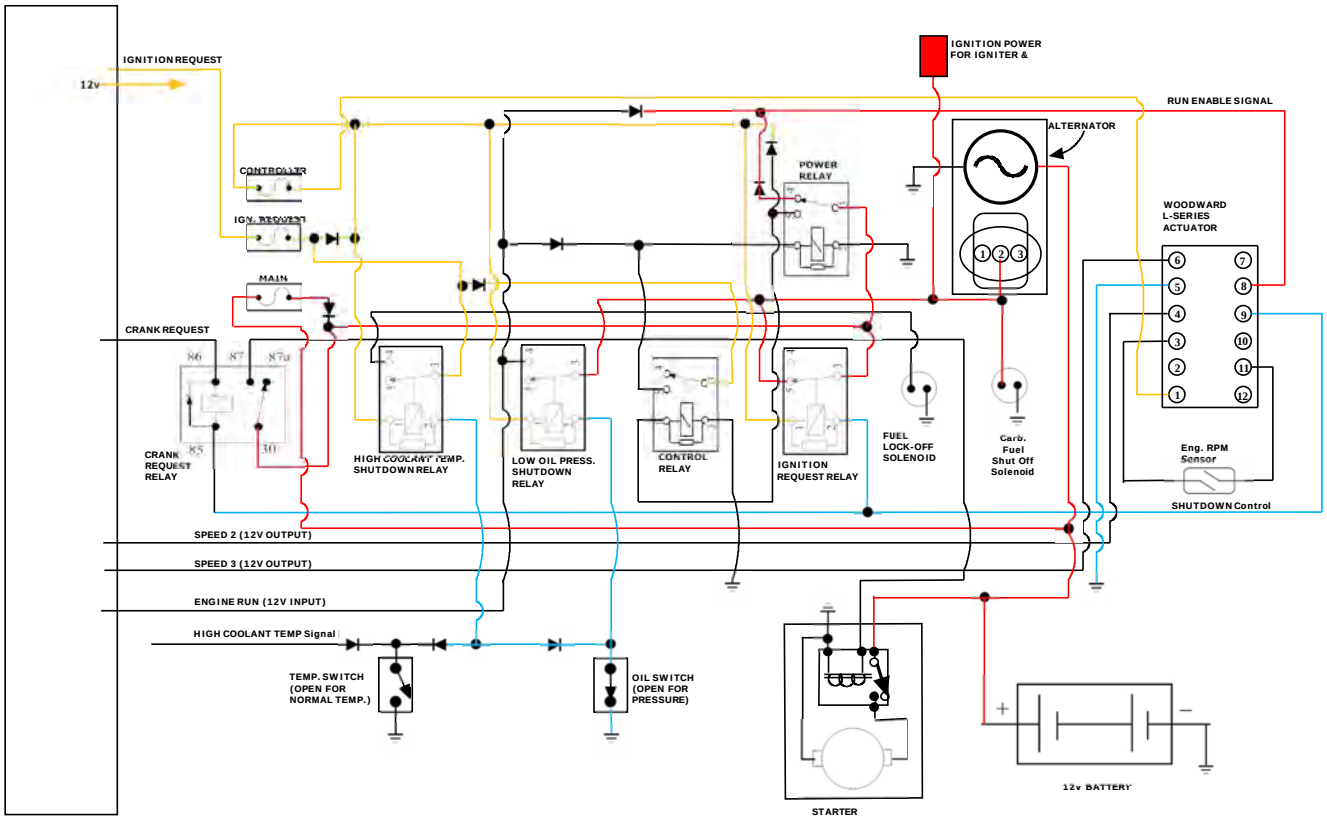
Ignition Off

- Battery power is available through the main fuse to the crank request relay common contact, the ignition request relay common contact and the power relay common contact.
- Battery power is provided to the “run enable” input of the L-Series actuator through the power relay closed at rest contacts. (If it doesn’t have this signal present on power up, it goes into an error mode.)
- There is no power to the fuel lock off solenoid.
- There is no power to the ignition system or carburetor fuel shut off solenoid.



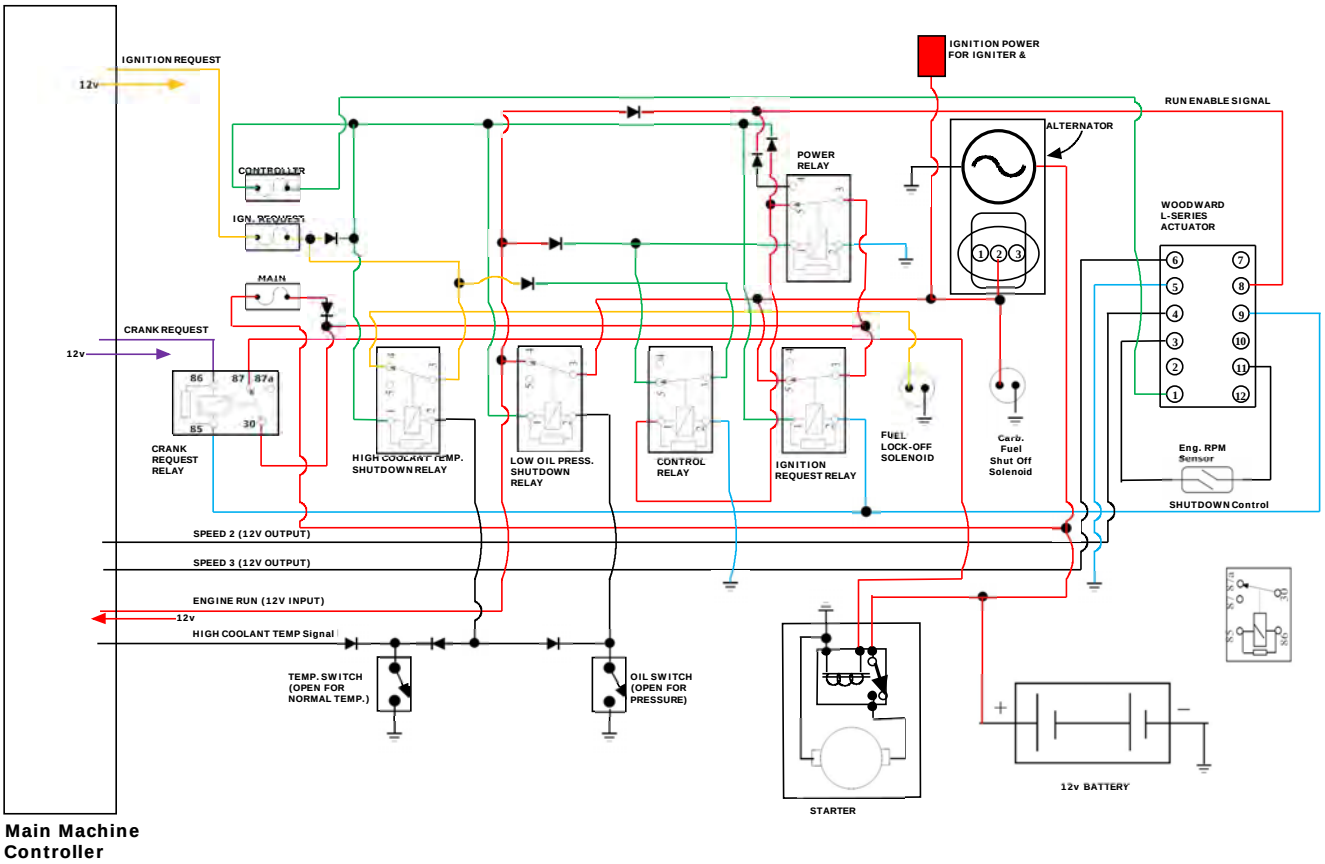
Ignition On

- When the main machine controller sees the key switch input, it sends 12v out on the Ignition Request circuit.
- When the actutor receives 12v at pin 1, it “wakes up”.
- The actuator provides a ground through itself for the shut down control circuit.
  - The ignition request relay is energized (as long as there is not a shutdown condition within the L-Series actuator) passing battery power to the ignition system, carburetor fuel shut off solenoid and the low oil press. shutdown relay common contact at pin 3.
- Ignition power is provided to the common contact at pin 3 of the high coolant temp. shutdown relay and the common contact at pin 3 of the control relay.
  - Since there is no oil pressure, the oil pressure switch is closed causing the Low oil pressure shutdown relay to be energized. This prevents power from being passed to the “engine run” input into the main machine controller.
  - The high coolant temp. shutdown relay coil is also grounded through the closed oil pressure switch causing it to be energized. This prevents power from being passed to the fuel lock-off solenoid.



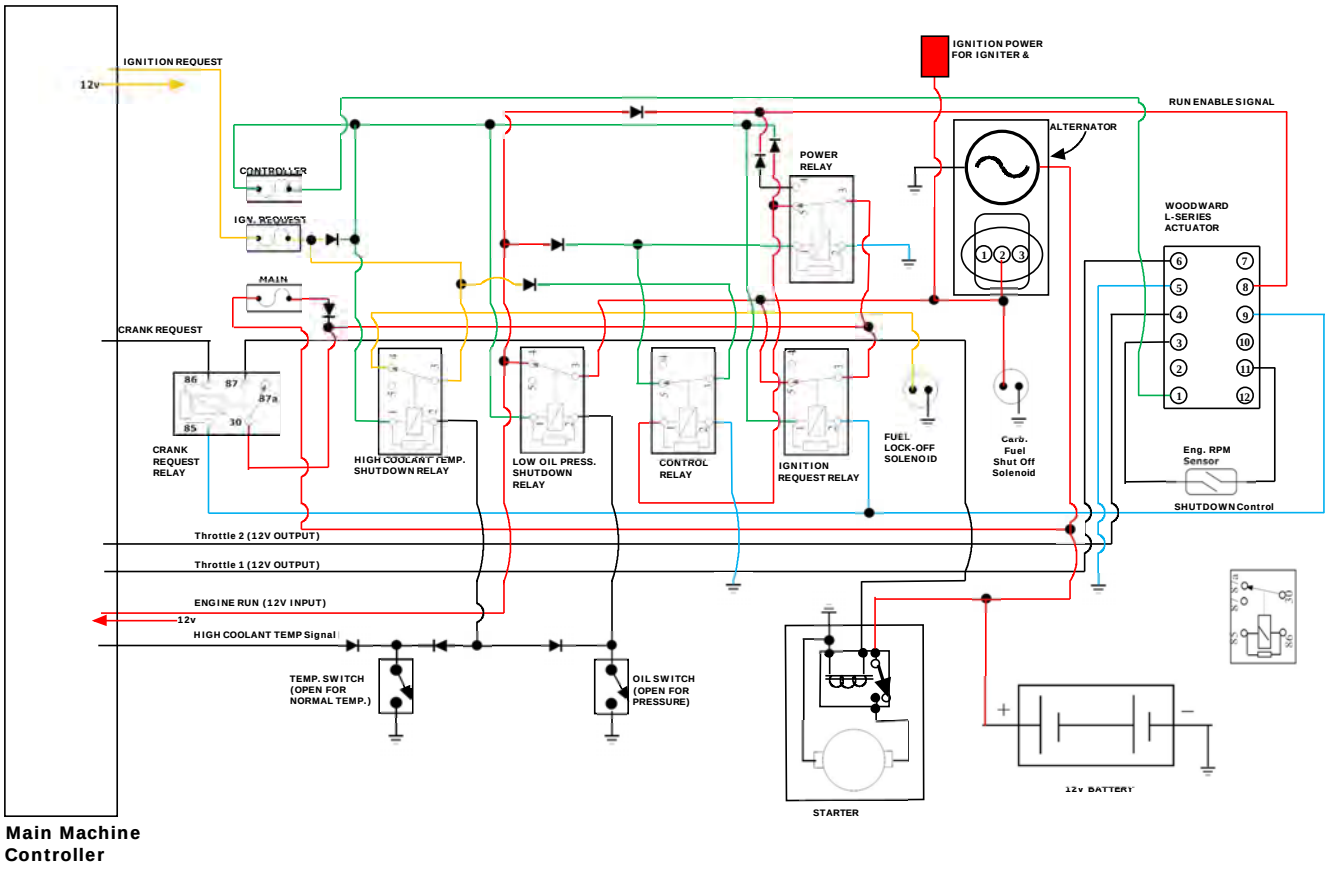
Cranking

- When the main machine controller sees the 36v cranking request from the key switch, it sends out 12v on the crank request circuit to the crank request relay winding. The other side of the winding is grounded through pin 9 of the actuator (as long as there is not a shutdown condition within the L-Series actuator). This energizes the crank request relay and battery power is passed through the contacts to the starter solenoid engaging the starter to turn the engine crankshaft. The ignition system is functional at this point, but there is not any fuel yet so the engine is not able to start.
- Once oil pressure builds up, the oil pressure switch opens.
  - The loss of ground through the oil pressure switch causes the high coolant temperature shutdown relay to de-energize. Ignition request power is then passed through the "closed at rest" contacts to the fuel lock off solenoid allowing fuel to flow and the engine to start.
  - The loss of ground through the oil pressure switch also causes the low oil pressure shutdown relay to de-energize.
    - Battery power is then passed through the "closed at rest" contacts to the main machine controller as the "engine run" signal and to the Woodward L series actuator.
      - From this point on, the "run enable" signal to the actuator is maintained by the low oil pressure shutdown relay.
    - The same power is also passed to the power relay coil energizing the relay.
      - Battery power is then passed through the "closed when energized" contacts of the power relay back into the ignition request circuit and to the control relay winding, energizing the control relay.



Normal Running

- When the key is released to the “run” position, the main machine controller turns off the voltage to the crank request circuit. This de-energizes the crank request relay and removes power from the starter solenoid.
- The rest of the circuit remains unchanged.



Engine RPM Control

The Woodward L-series actuator directly monitors the engine speed sensor input and adjusts the throttle linkage to maintain the current target engine speed. If it is unable to maintain the speed within the desired “window”, it will shut the engine down by removing the path to battery negative for the ignition request relay through the actuator. Note that if the actuator loses the RPM signal while the engine is running, it will shut the engine down. If the actuator never sees an RPM signal, it does not know that the engine is running and has not tried but failed to control the RPM. Therefore it remains in a “cranking mode” and does not shut the engine down.

The main machine controller communicates the desired engine speed mode to the actuator via the Throttle 1 and Throttle 2 wires. It either sends out 0v or 12v on each wire, depending on the desired speed mode.

Speed Mode	Engine Speed	Throttle 1	Throttle 2
Idle	1700 RPM	0	0
Run	2500 RPM	0	12v
Maximum Power	2700 RPM	12v	12v

There are several conditions that will override the user's engine speed request.

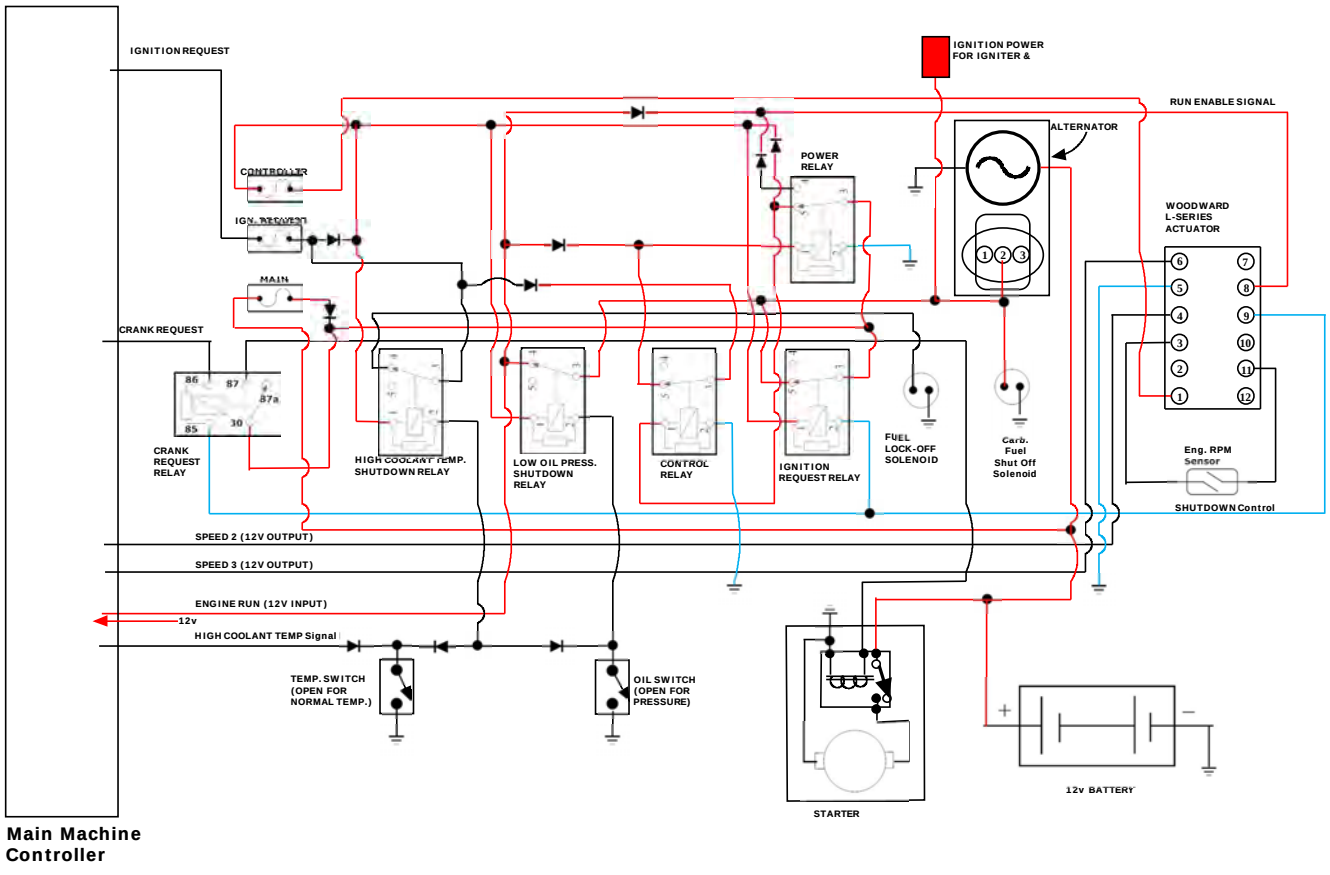
- High pressure wash forces to run speed.
- If the engine is at idle speed, the engine will be forced to the run speed when sweeping only or vacuuming only. The force idle (neutral timeout) will return the engine to idle speed.
- If the engine is at idle or run speed, the engine will be forced to maximum power speed when scrubbing only or scrubbing and sweeping. The force idle (neutral timeout) will return the engine to idle speed.
- If the override is run speed, the user can change between maximum power speed and run speed.
- If the override condition goes away (e.g. sweep system turns off) and the user has not changed the engine mode, the engine is returned to the mode before the forced override.

Normal Engine Shut Off

Step One

When the key switch is shut off, the main machine controller stops sending 12v out the ignition request circuit. This removes the power source for the fuel lock off solenoid that had been flowing through the "closed at rest" contacts of the high coolant temp shut down relay. No more fuel will flow into the vaporizer/regulator but the engine continues to run on the fuel that is "trapped" in the regulator.

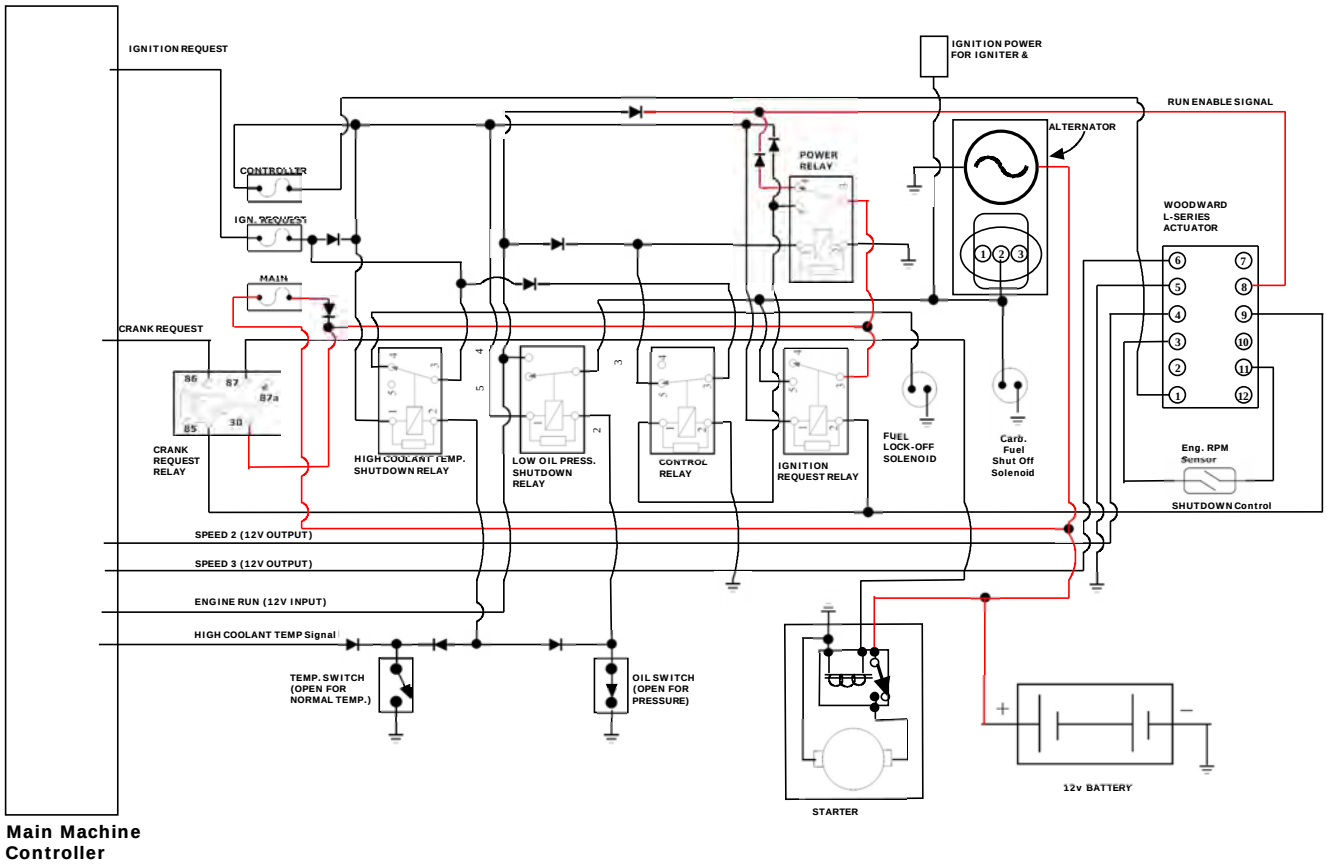
You may recall that when the key was first turned on, that the ignition request voltage energized the ignition request relay and provided power for the ignition system. If this is true, how can the engine stay running after the ignition request voltage is shut off by the main machine controller? It is able to stay running because the energized power relay is providing battery power to the ignition request relay keeping it energized so that the ignition system is still powered up.



Step Two

The engine continues to run until it uses up the fuel that was trapped in the vaporizer/regulator. When the engine stalls, and loses oil pressure, the oil pressure switch closes, energizing the low oil pressure shut down relay. This removes power from the power relay coil causing it to de-energize and remove power from the ignition request relay. This de-energizes the ignition request relay causing the ignition system to shut down and turns off the carburetor fuel shut off solenoid stopping the flow of any remaining fuel.

When the power relay de-energized, it also removed power from the control relay coil, low oil pressure shut down relay coil, high coolant temp shut down relay coil and pin 1 of the Woodward L series actuator. This "turns off" the actuator which, releases the switched to ground connection through pin 9 of the actuator.



Engine Protection Modes

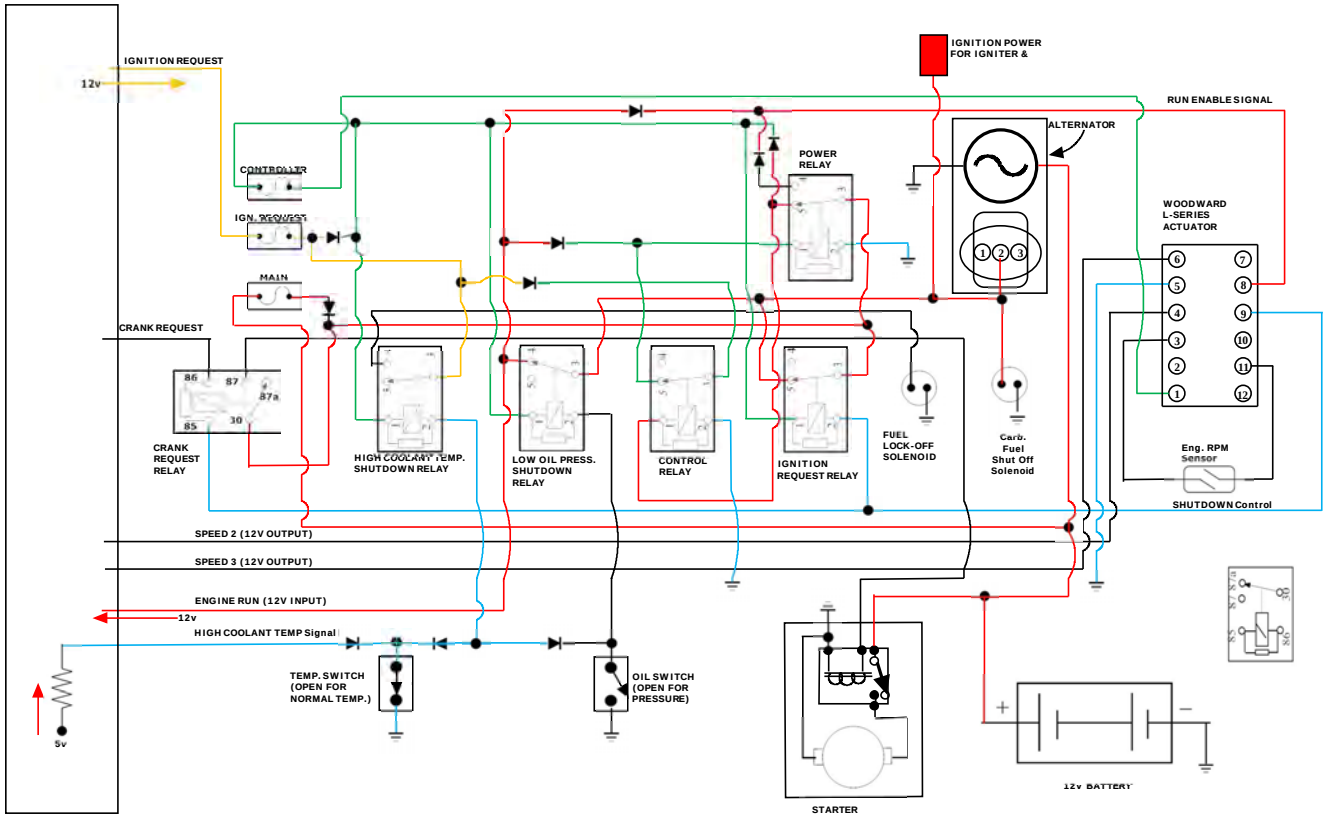
The engine will be shut off in the event that it overheats or loses oil pressure after it has been running. The main machine controller will display a warning message to the operator for either case and will also initiate an engine shut down as a back up measure.

In the case of lost oil pressure, the Woodward L series actuator disables the ignition system by de-energizing the Ignition Request relay.

In the case of the engine overheating, the high coolant temperature shut down relay shuts the engine off by removing power from the fuel lock off solenoid causing the engine to run out of fuel and stall.

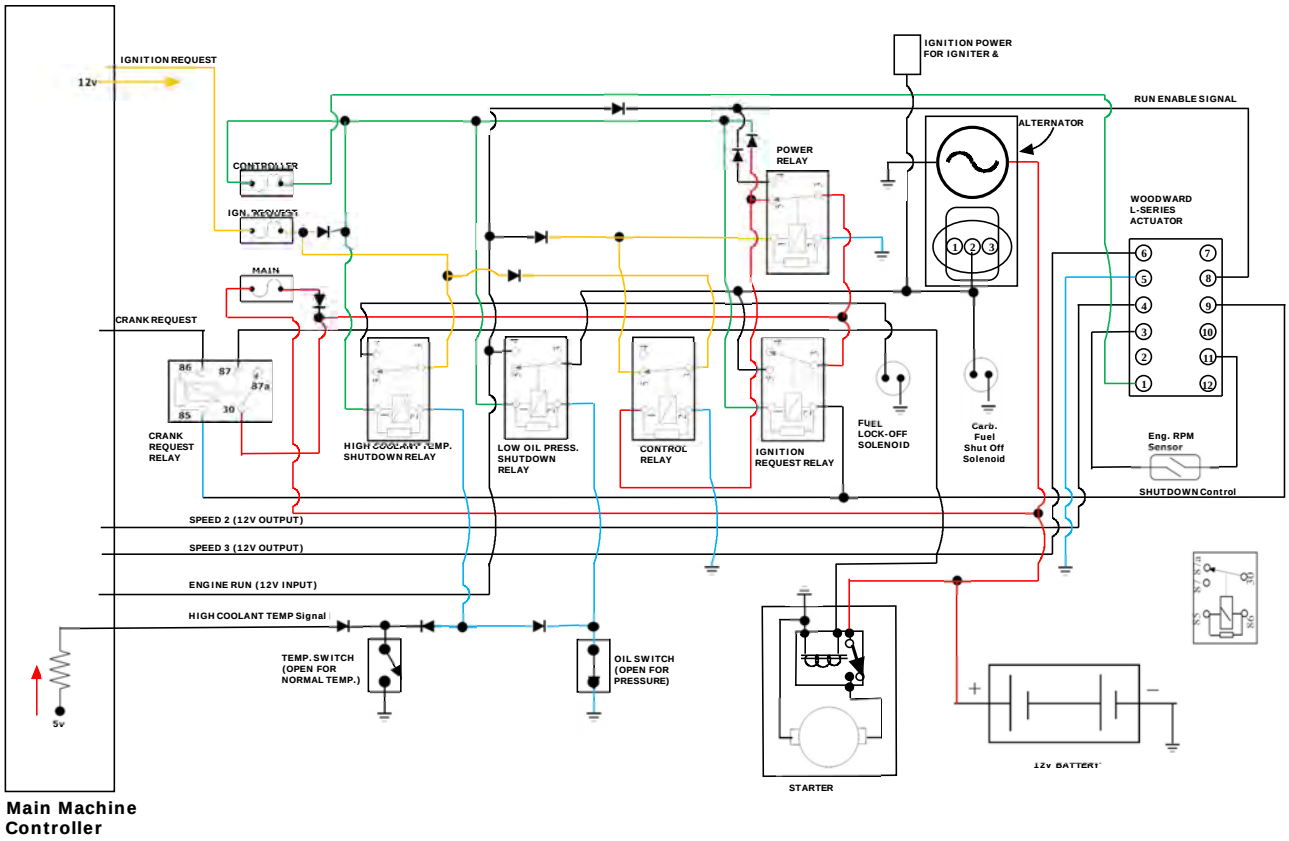
Engine Overheat Shutdown

- If the engine overheats, the temperature switch closes. This completes a path to ground for the high coolant temp shut down relay and energizes the relay. This removes power from the fuel lock off solenoid. This does not shut the engine down immediately, but allows the engine to use up the fuel trapped in the regulator before stalling due to lack of fuel.
- The main machine controller monitors the engine coolant temperature by sending out a 5v feed through an internal resistor to the temperature switch. When the switch closes the voltage on the switch side drops from 5v to 0v . In response, the main machine controller sets an overheat code and alerts the operator. After a 5 second delay, it removes the 12v Ignition request signal. If the engine has not already shut down, the system will then shut down as if the operator had shut off the key (Normal engine shut off).

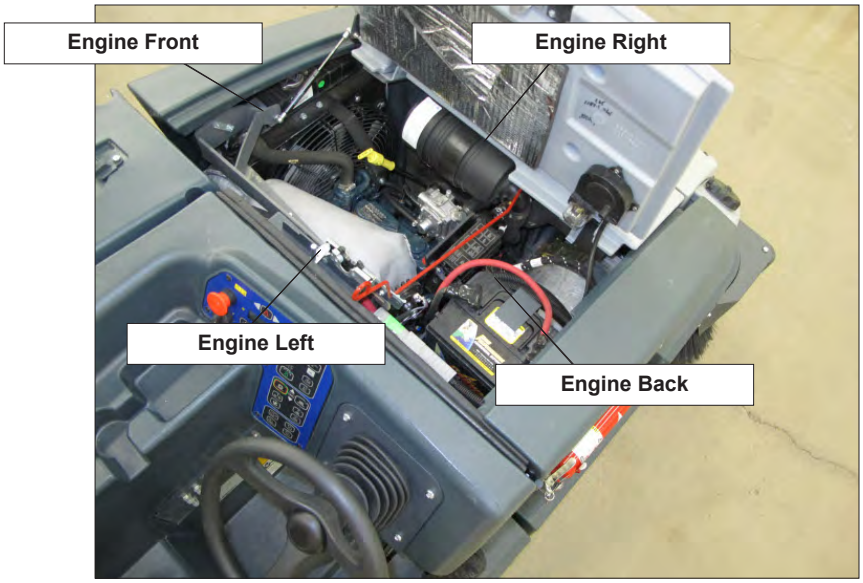


Lost Oil Pressure Shutdown

- If the engine oil pressure is lost, the oil pressure switch will close causing the low oil pressure shut down relay to energize taking power away from the “closed at rest” contact. This removes the power from the run enable signal to pin 8 of the Woodward L series actuator. The actuator immediately switches off the internal ground for the shut down control circuit at pin 9 causing the ignition request relay to de-energize. This shuts down the ignition system and the carburetor fuel shut off solenoid causing engine to stall immediately. The high coolant temp shut down relay also energizes, removing power through the closed at rest contacts to the fuel lock off solenoid.
- When the low oil pressure shut down relay energizes, power is also lost for the engine run signal to the main machine controller. The loss of the engine run signal is interpreted as “loss of oil pressure” by the main machine controller. It responds by immediately displaying an engine warning message to the operator and removing the 12v power going out to the ignition request circuit. If the engine has not already shut down, the system will then shut down as if the operator had shut off the key (Normal engine shut off).



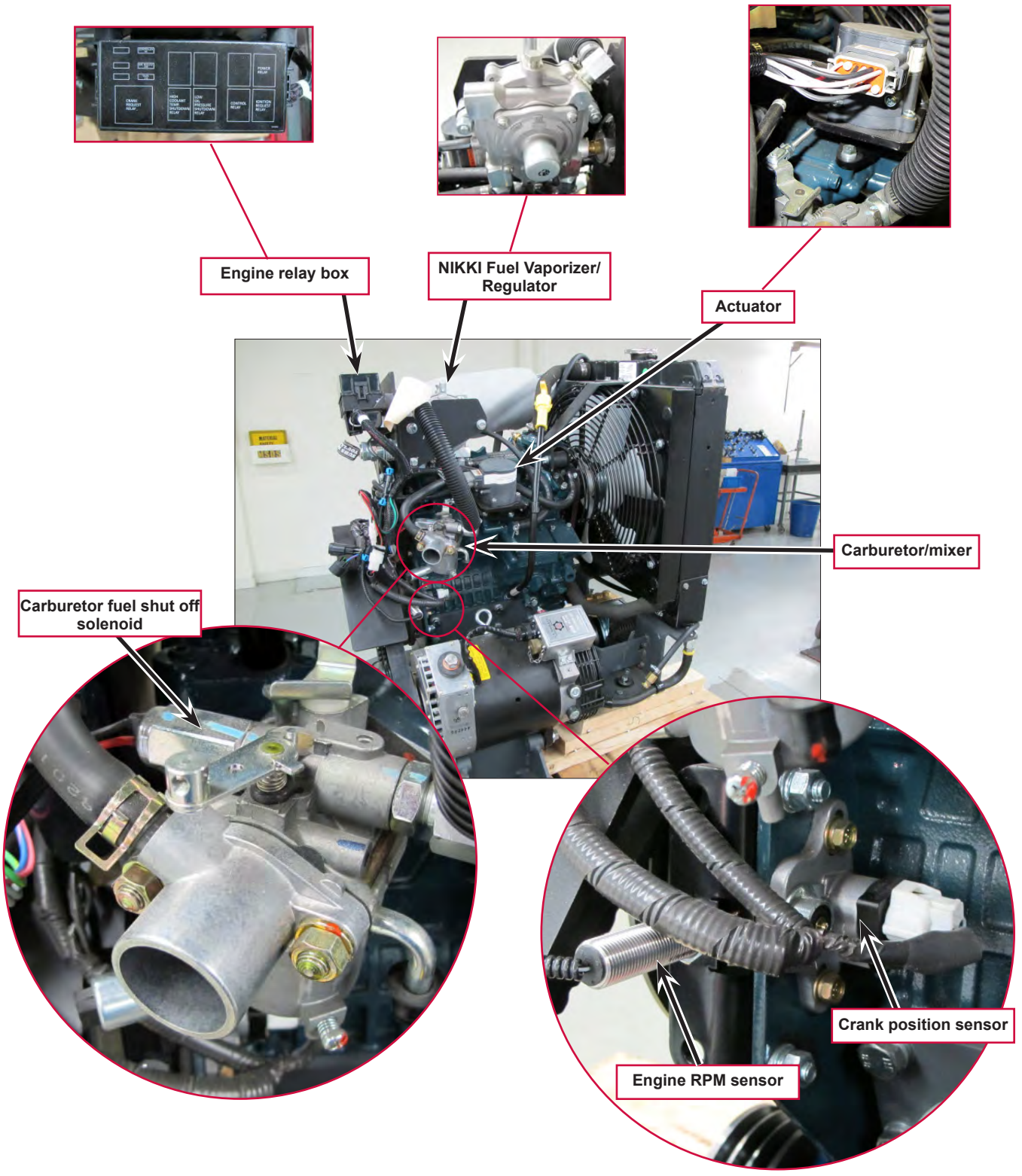
Component Locations



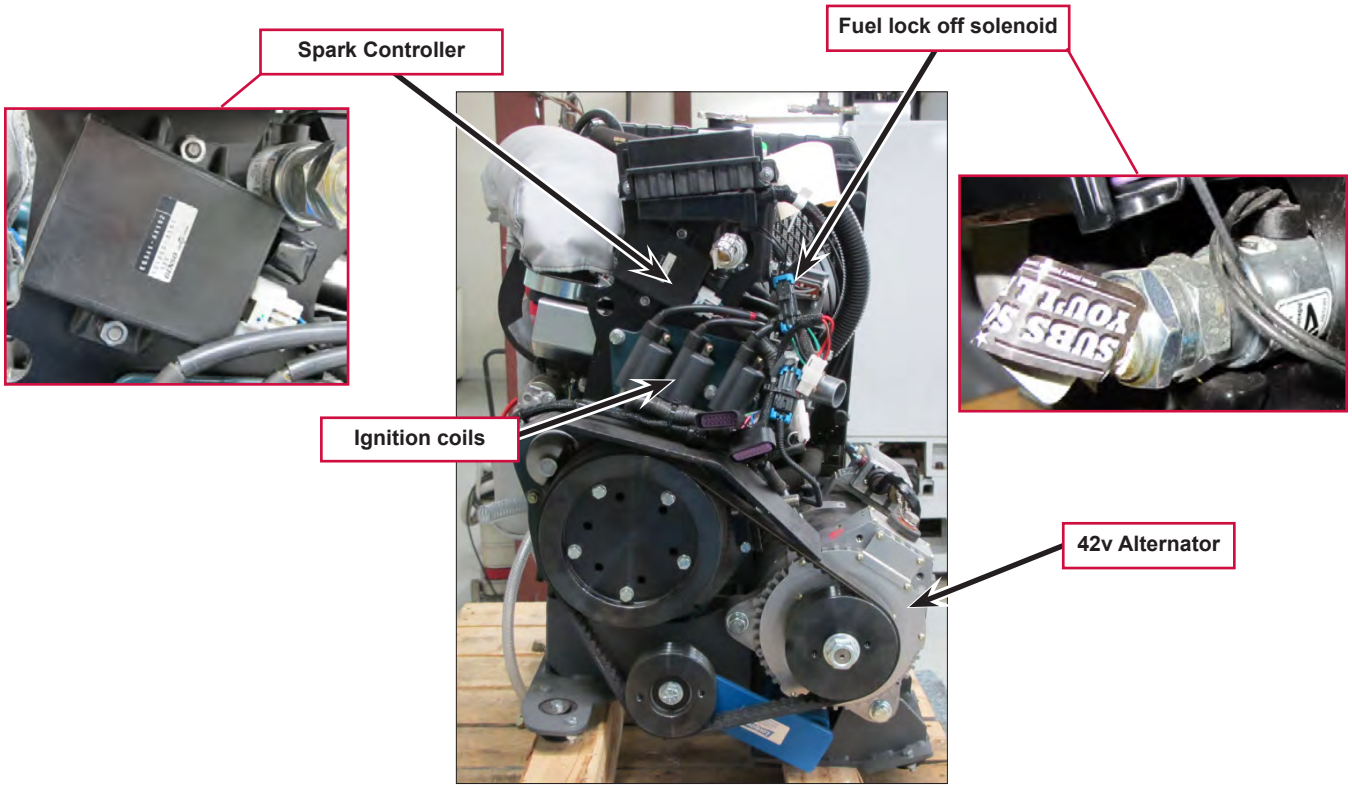
Engine components are grouped according to the area of the engine. They are photographed on an engine that is not installed in the machine for better visibility. See next pages for photos.

- **Engine Right** Side View (Toward front of machine)
  - Engine relay box
  - NIKKI Fuel Vaporizer/Regulator
  - Actuator
  - Carburetor/mixer
  - Engine RPM sensor
  - Crank position sensor
  - Carburetor fuel shut off solenoid
- **Engine Back** Side View (Toward right of machine)
  - Spark Controller
  - Fuel lock off solenoid
  - 42 V Alternator
  - Ignition coils
- **Engine Left** Side View (Toward back of machine)
  - 12 V alternator
  - Engine starter
  - Oil pressure switch
  - Coolant temperature switch
- Fuel Tank Area
  - Fuel tank
  - Pressure relief valve
  - Low LPG pressure switch

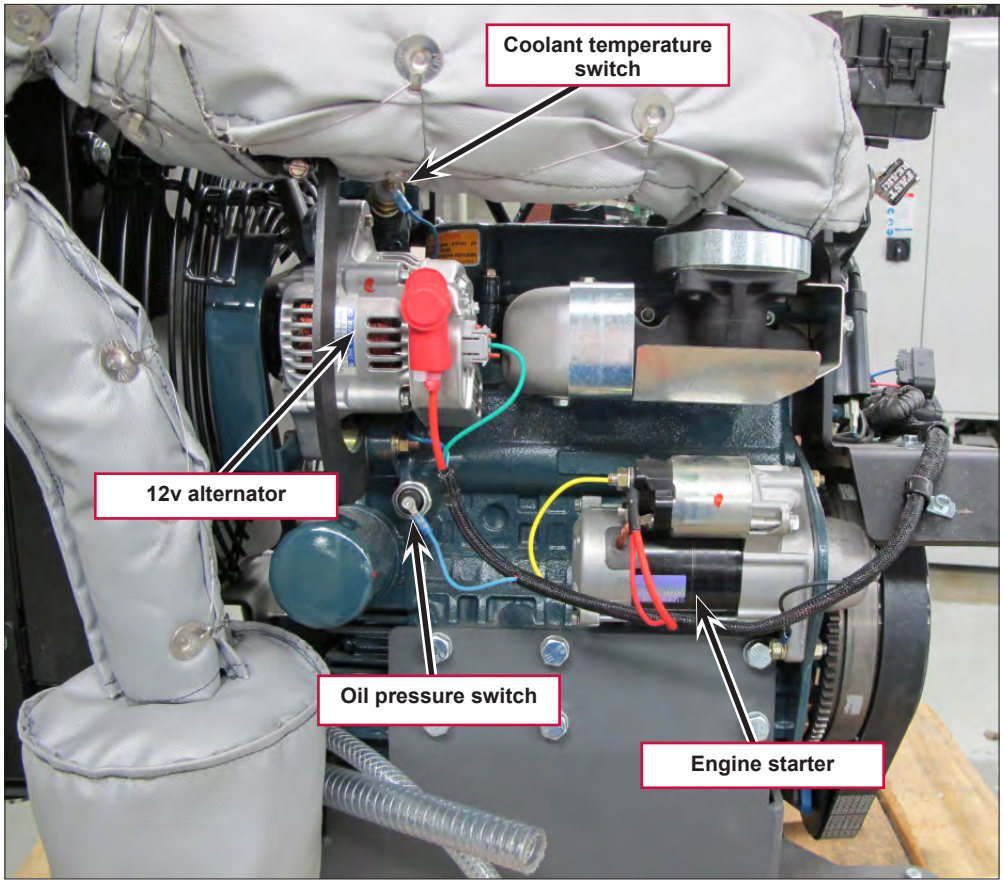
Engine Right Side View (Toward front of machine)



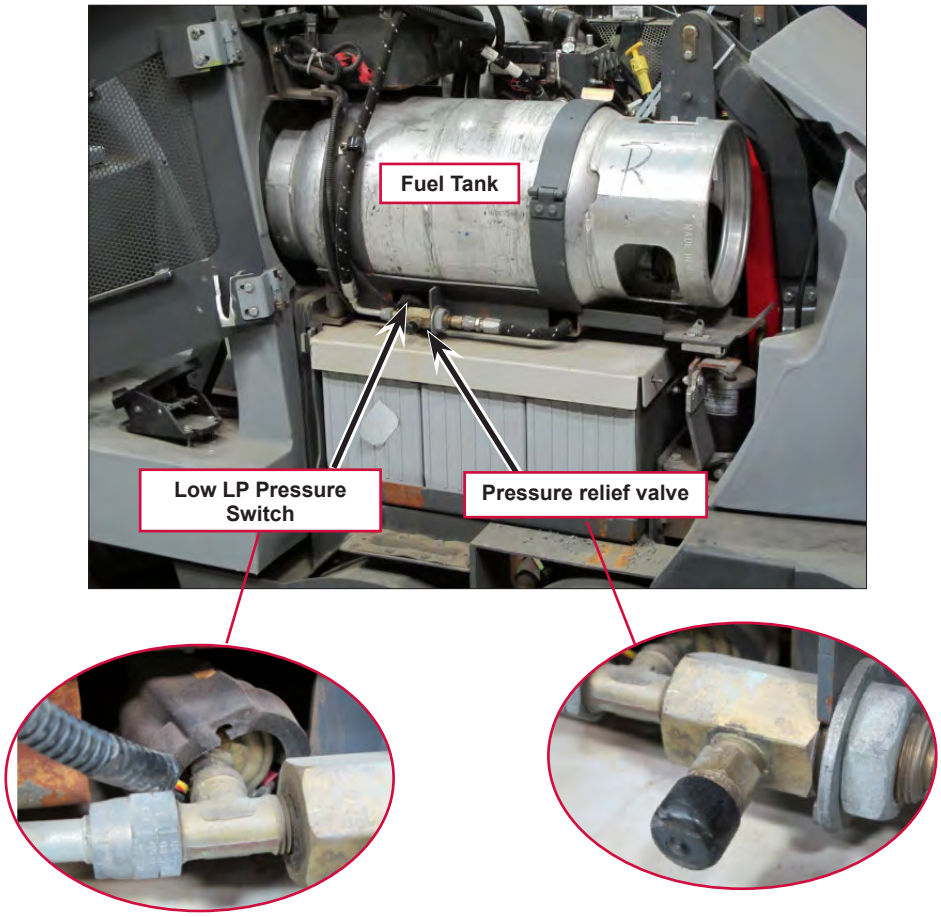
Engine Back Side View (Toward right of machine)



Engine Left Side View (Toward back of machine)



Fuel Tank Area



Maintenance and Adjustments

Maintenance Checklist

This check list is courtesy of the Kubota engine Workshop Manual. See the workshop manual for more details on performing these operations.

Daily:

- Check engine oil level
- Check and replenish coolant
- Check air cleaner element
- Check LPG tank setting condition
- Check LPG fuel connector

First 50 hours:

- Change engine oil
- Replace engine oil filter

Every 50 hours

- Clean air cleaner element
- Check LPG fuel hose and clamp bands
- LPG fuel check

Every 100 hours

- Clean spark plug
- Check fuel filter
- Check fan belt tension and damage

Every 200 hours

- Change engine oil
- Replace engine oil filter
- Check LPG tank setting condition
- Check radiator hoses and clamp bands

Every 1 year

- Replace air cleaner element
- Clean carburetor
- Clean water jacket and radiator interior

Every 1000 hours

- Replace spark plug
- Check coolant hose of LPG vaporizer
- Check vacuum lock hose of LPG vaporizer
- Drain tar
- Check valve clearance
- Clean cylinder head
- Check valve seats

Every 2 years

- Replace intake air line
- Replace LPG fuel hose and clamp bands
- Replace coolant hose of LPG vaporizer
- Replace vacuum lock hose of LPG vaporizer
- Check primary chamber
- Check air tight of secondary chamber
- Check vacuum lock system
- Replace radiator hoses and clamp bands
- Replace battery
- Change radiator coolant (L.L.C.)

Change Engine Oil and Oil Filter

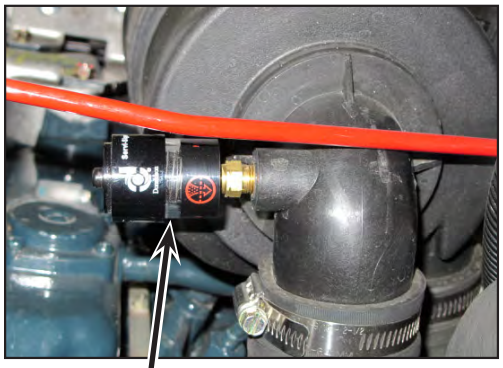
1. Drain the recovery tank for later removal.
2. Shut off the engine and allow it to cool sufficiently to avoid burning yourself with hot engine oil.
3. Remove the left side engine cover.
4. Tip the recovery tank outward. Release the recovery tank tether cable and recover hose, then lower the recovery tank to the ground for better access to the engine oil filter area.
5. Remove the oil filter with an oil filter wrench.
6. Apply a light coat of engine oil to the new filter cartridge gasket.
7. Screw the new cartridge on and tighten by hand. Over tightening may damage the gasket.
8. Remove the remote oil drain hose end from the radiator bracket.
9. Remove the plug and drain the oil into a suitable container.
10. Reinstall the plug-and reattach the drain hose to the radiator bracket.
11. Refill the engine with oil.

Change Engine Coolant

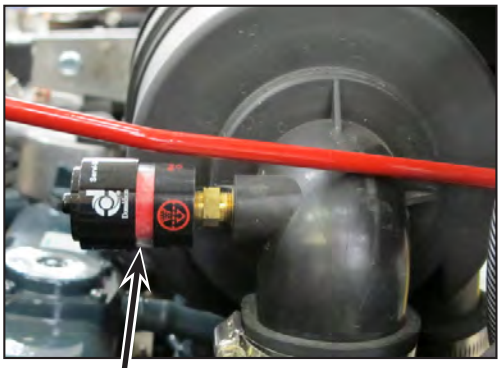
1. Allow the engine to cool sufficiently to relieve cooling system pressure and avoid burns.
2. Remove the left side engine cover.
3. Remove the radiator cap.
4. Locate the remote engine coolant drain hose, remove the plug and direct the coolant into a suitable container.
5. Reinstall the drain plug and reposition the drain hose.
6. Refill with a 50/50 mixture of engine antifreeze and water.

Inspect Air Filter

Check the service indicator mounted on the air cleaner elbow. If the red disc is visible in the “window”, the filters should be cleaned or replaced.



Clear Window = Okay



Red in Window = Restricted Filters

Replace Air Filters

1. Release the latches and remove the air filter housing cover.
2. Remove the outer filter element.
3. Blow out air cleaner housing with compressed air with inner filter element still in place to prevent dirt from entering the engine air intake.
4. Remove the inner filter element.
5. Clean residual dust from the inside of the air cleaner housing, taking care to prevent any dirt or debris from entering the air intake.
6. Install a new inner filter element and then the new outer filter element making sure that they seal well at their ends.
7. Install the air cleaner housing cover.

Troubleshooting

Checking Spark

1. Remove the spark plug wire from the spark plug and insert an adjustable KV tester in the end of the wire.
2. Adjust the gap to approximately 20 - 30 KV and clip the tester to a good ground on the engine.
3. Crank the engine over and check for consistent arcing across the tester gap.

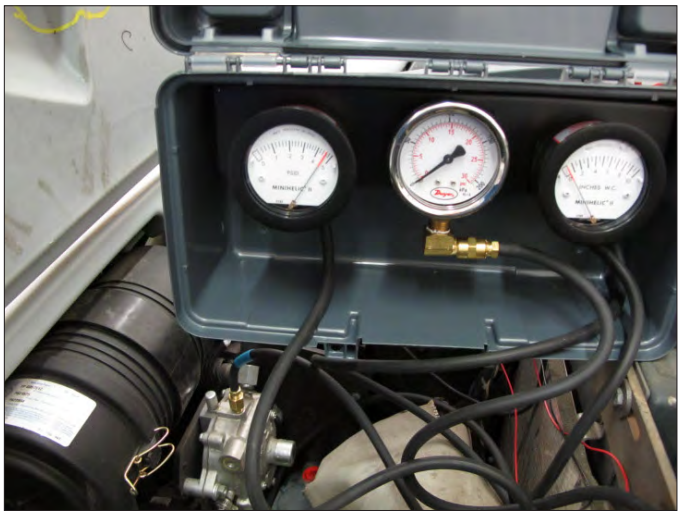
Checking LPG Primary Pressure

1. Turn off the propane tank valve with the engine running and allow the engine to run out of fuel.
2. Turn key switch off.
3. Remove the primary chamber test port plug located on top of the vaporizer regulator.

4. Install thread adapter part number 50360A into the test port.

5. Install fitting from LPG pressure test kit into the thread adapter.

6. Using the LPG test gauge kit - Part # 56504450, hook up the blue pressure gauge hose to fitting.
7. Open propane tank valve.
8. Start engine. (Specification - 4.3 PSI, 32.7kPA)
9. When finished, reinstall the test port plug using a suitable pipe thread sealant. (E.G. Loctite 30534)



No crank - The starter does not engage

Possible causes:

- 36v battery pack drained (preventing main machine controller from powering up.)
- Engine Battery
- Starter
- Battery to starter cable
- Engine Ground
- No voltage to the starter solenoid
  - Open circuit breaker CB9
  - Auxiliary Relay
    - Burned contacts or not energized
  - Key Switch
  - Main Machine Controller
  - Woodward L Series Actuator (Not supplying ground for crank request relay)
  - Crank request relay
- Wiring

Cranks but does not start – No Spark

Possible causes:

- Spark Control Module not powered up.
  - Ignition request relay
  - Woodward L Series Actuator not energizing ignition request relay
  - Spark control module ground
- Crank Position Sensor
- Spark Control Module
- Wiring
- Ignition Coils (not likely that all 3 coils would fail at once)

Cranks but does not start (has sufficient spark)

Possible causes:

- No fuel
  - Empty Tank
  - Fuel lock off solenoid stuck closed
  - Fuel lock off solenoid not energized
    - Ignition request fuse – blown
    - High coolant temp shut down relay – “Closed at rest” contacts not making connection
    - Engine oil pressure switch - not opening for pressure
    - Engine – Insufficient oil pressure to open switch
  - Pressure Regulator
- Mechanical engine
  - Insufficient compression
  - Plugged Intake
  - Plugged Exhaust
- Actuator
  - Not opening throttle

Achieves one but not ALL RPM modes.

The approach to diagnosing an engine RPM control problem is to check the inputs to the L series actuator. If the inputs are good and the output is bad, the conclusion is that the actuator is the problem. However, don't forget that insufficient fuel supply or a restricted exhaust could appear like an RPM control problem if the engine cannot run well enough to achieve a higher RPM.

Possible Causes:

- Failed Engine Speed Sensor
- Actuator linkage
- Actuator power supply
- Actuator
- Wiring
- Main Machine Controller

Diagnostic steps

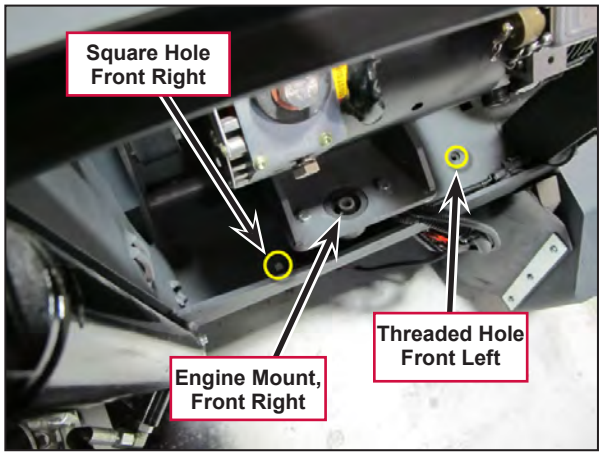
1. Visually inspect the linkage between the actuator arm and the carburetor throttle lever.
   - Is the linkage okay?
     - If not, repair
     - If so, go to next step.
2. Check the power and ground supplies to the actuator.
   - Is there sufficient power and ground?
     - If so, go on to check the Engine RPM Sensor input.
     - If not, repair.
3. Check the Engine RPM Sensor input. (Check the AC voltage while the engine is running or check resistance of sensor through wiring harness from the actuator connector.)
   - Is the Engine RPM sensor input okay?
     - If so, go on to check the speed request inputs.
     - If not, repair.
4. Check the speed request inputs - With the engine running press the engine speed button and check for 12v to the throttle 1 wire at the actuator.
   - Is 12v present on the throttle 1 wire?
     - If so, replace the actuator
     - If not, check the wiring between the main machine controller and the governor controller.
     - If the wiring is okay, check the output coming out of the main machine controller.

Removal and Installation

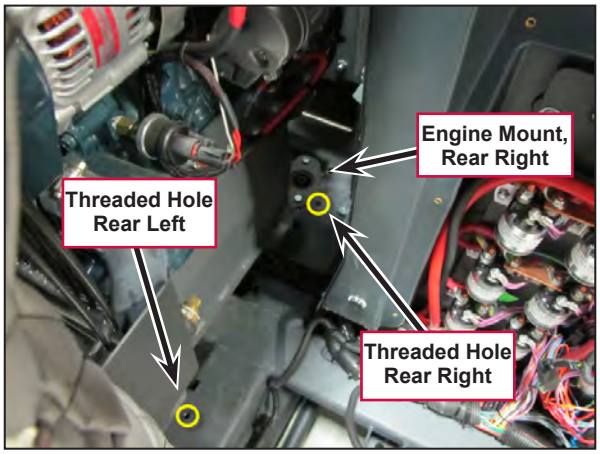
Engine Assembly

The complete engine including the exhaust, radiator and 42v alternator are removed as an assembly. There is no need to drain engine oil or coolant. The assembly is attached to the chassis at 4 rubber motor mounts. The front right mount has a square hole in the chassis for a carriage bolt. The other 3 are threaded holes in the frame.

1. Remove engine Top cover
2. Disconnect the 36v battery pack main positive and negative cables.
3. Disconnect the 12v battery negative cable.
4. Disconnect the 12v battery positive cable.
5. Disconnect fuel supply and return lines.
6. Disconnect battery positive and negative cables at the starter.
7. Disconnect the engine wiring connectors.
8. Remove the 4 motor mount fasteners. (Note: photos are of diesel engine)



Front engine mounting locations. Shown with hopper up and engine being installed.



Rear engine mounting locations. Shown with engine being installed.

9. Lift the assembly out of the chassis using a suitable hoist attached to the two engine lift points.
10. Reassemble in reverse order. Connect the battery negative cables last.

Specifications

Fuel System

Primary Chamber Pressure - 4.3 PSI (32.7 kPA)

Fuel Lock Off Solenoid Resistance - 10 ohms

Engine Oil

Engine oil capacity - 3.4 L, 0.90 U.S.gals

- IMPORTANT
  - When using an oil of different maker or viscosity from the previous one, remove all of the old oil.
  - Never mix two different types of oil.
  - Engine oil should have properties of API classification SH or better.
  - Use the proper SAE Engine Oil according to ambient temperature.

Above 25 °C (77 °F) - SAE30 or SAE10W-30

0 °C to 25 °C (32 °F to 77 °F) - SAE20 or SAE10W-30

Below 0 °C (32 °F) - SAE10W or SAE10W-30

Engine Coolant

Use only ethylene glycol or propylene glycol type anti-freeze for this engine. Always assure a 50% / 50% anti-freeze and water mixture regardless of temperature.

Shop Measurements

The following information provides some “real world” shop measurements to help you recognize what “normal” looks like.

Ignition System

Ignition coil primary resistance – 2.15 ohms

Ignition coil secondary resistance – 18.4 K ohms

Spark Output - 30 KV consistently (Using adjustable spark tester)

Crank position sensor resistance - 2.18 K ohms

Crank position sensor output cranking - 1.1 VAC average. 2.0 VAC RMS

Crank position sensor output running - 5.5 VAC average

Spark Controller Measurements:

Pin Letter	Wire Color on machine	Circuit	Voltage with key on unplugged
E	BLU	Crank Position Sensor	0v
F	BLK	Ground (And other leg of Crank sensor)	0.004v
G	Red	Power Supply	11.2v
H	Not used		
I	Not used		
J	BLU/BLK	Coil 3 Driver	11.2v
K	WHT/BLK	Coil 2 Driver	11.2v
L	RED/BLK	Coil 1 Driver	11.2v

Governor Control System

Woodward L Series Actuator Measurements

Pin	Wire Color	Circuit Description	Connector Unplugged Key On	Connector Plugged In Key On
1	PNK/BLK	Ignition Request	11.69v	11.4v
2	Not used			
3	BLK	Engine RPM Sensor	-	-
4	GRA/BLU	Throttle 2	7.79v	0.007v
5	BLK	Ground	0.007v	0.007v
6	GRA/ORN	Throttle 1	7.78v	0.007v
7	Not used			
8	GRA/WHT	Run Enable Signal	11.9v	11.0v
9	BLK/WHT	Shut Down Signal	11.6v	0.028v
10	Not Used			
11	CLR	Engine RPM Sensor	-	-
12	Not Used			

RPM Sensor Output (measured at the actuator Pin 3 and 11 with the connector plugged in):

- 0.68v AC when cranking
- 2.13v AC when running

Engine RPM sensor resistance - 2.07 K ohms

Fuel System

Carburetor LPG shut off solenoid resistance – 27.3 ohms

Fuel Lock Off Solenoid resistance - 10.1 ohms

Primary Pressure - 4.6 PSI

Engine

Engine Vacuum at idle - approx 14.5 - 15” HG

When returning from low RPM to idle vacuum momentarily peaks around 21” HG

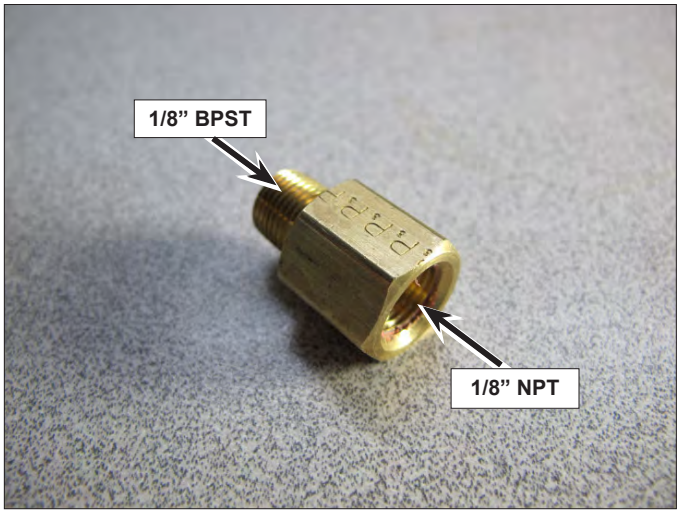
Engine Compression

- Cyl #1 - 170 PSI
- Cyl #2 - 170 PSI
- Cyl #3 - 170 PSI

Special Tools

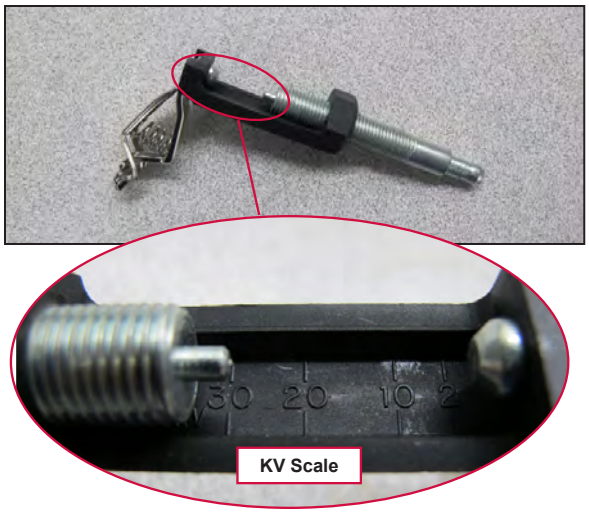
LPG test gauge kit - Part # 56504450

LPG test port adapter. (Male 1/8” BSPT to Female 1/8” NPT) Part # 50360A



Adjustable KV Spark Tester.

Most automotive parts suppliers sell these tools. Shown is 50850 from Lisle corporation. http://www.lislecorp.com/



Engine System - Petrol (Gasoline)

This chapter covers the things “on top” of the mechanical engine that make it run, such as the fuel system, governor control and ignition system. It also includes routine engine maintenance information and troubleshooting of engine starting or running problems. See the Kubota WG972 E3 Workshop Manual 9Y111-05710 for detailed information related to the complete mechanical engine.

Functional Description

Kubota WG972-GL-E3-NFK-1 Petrol (Gasoline)

The Kubota WG972 is a three cylinder, liquid cooled, naturally aspirated engine. The fuel system does not utilize a control module. It is mechanically controlled. The ignition system is “self-contained”. That is, it has no interaction with the fuel system and shares no components with it.

The fuel system begins with a petrol (gasoline) fuel tank which is horizontally mounted on the right side of the engine compartment. The tank swings out to provide easier access to the engine compartment. An electric fuel pump is mounted to the top of the tank. The tank contains a fuel level sending unit. The carburetor has an additional fuel shut off solenoid that must be energized for petrol to flow through the carburetor to the engine.

Kubota Engine

Gasoline (Petrol) Fuel Tank

Carburetor

The engine RPM is controlled with a Woodward L-Series governor/speed actuator based on requests from the main machine controller. The main machine controller sends signals to the Woodward L-Series governor/speed actuator to request one of three engine speeds based on operator request or cleaning mode. The actuator has a “built in” microprocessor which receives the requests and in turn physically moves the carburetor/mixer throttle blade to achieve the requested engine speed.

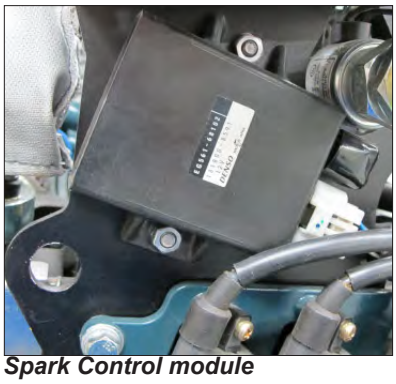
The cooling system consists of a standard radiator and belt driven fan. Note that the fan pushes air away from the engine and out through the radiator.

Woodward L Series Actuator

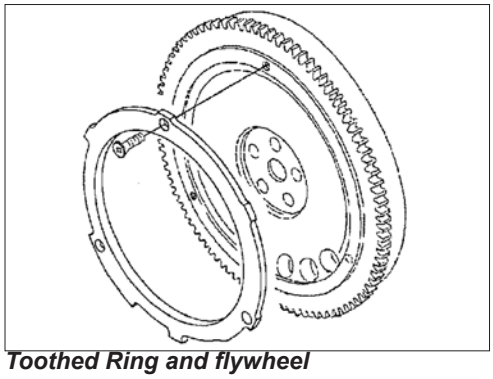
Circuit Descriptions

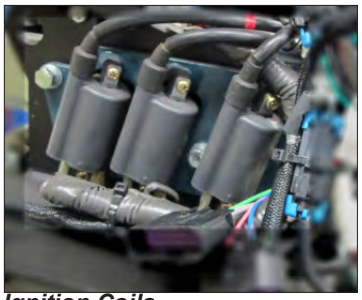
Ignition System

The ignition system consists of a spark control module (aka Ignitor), three ignition coils, and a crank position sensor. The crank position sensor reads a rotating 6 toothed ring which is mounted on the flywheel between the flywheel and the engine.


Spark Control module

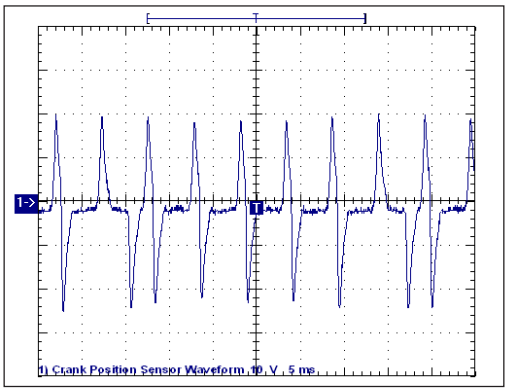
Crank Position Sensor


Toothed Ring and flywheel


Ignition Coils

The heart of the system is the spark control module. It controls the current flow of each ignition coil primary circuit in order to control when spark occurs based on inputs from the crank position sensor. Each coil fires twice per cylinder cycle. Once to initiate the power stroke and once in exhaust stroke (waste spark)

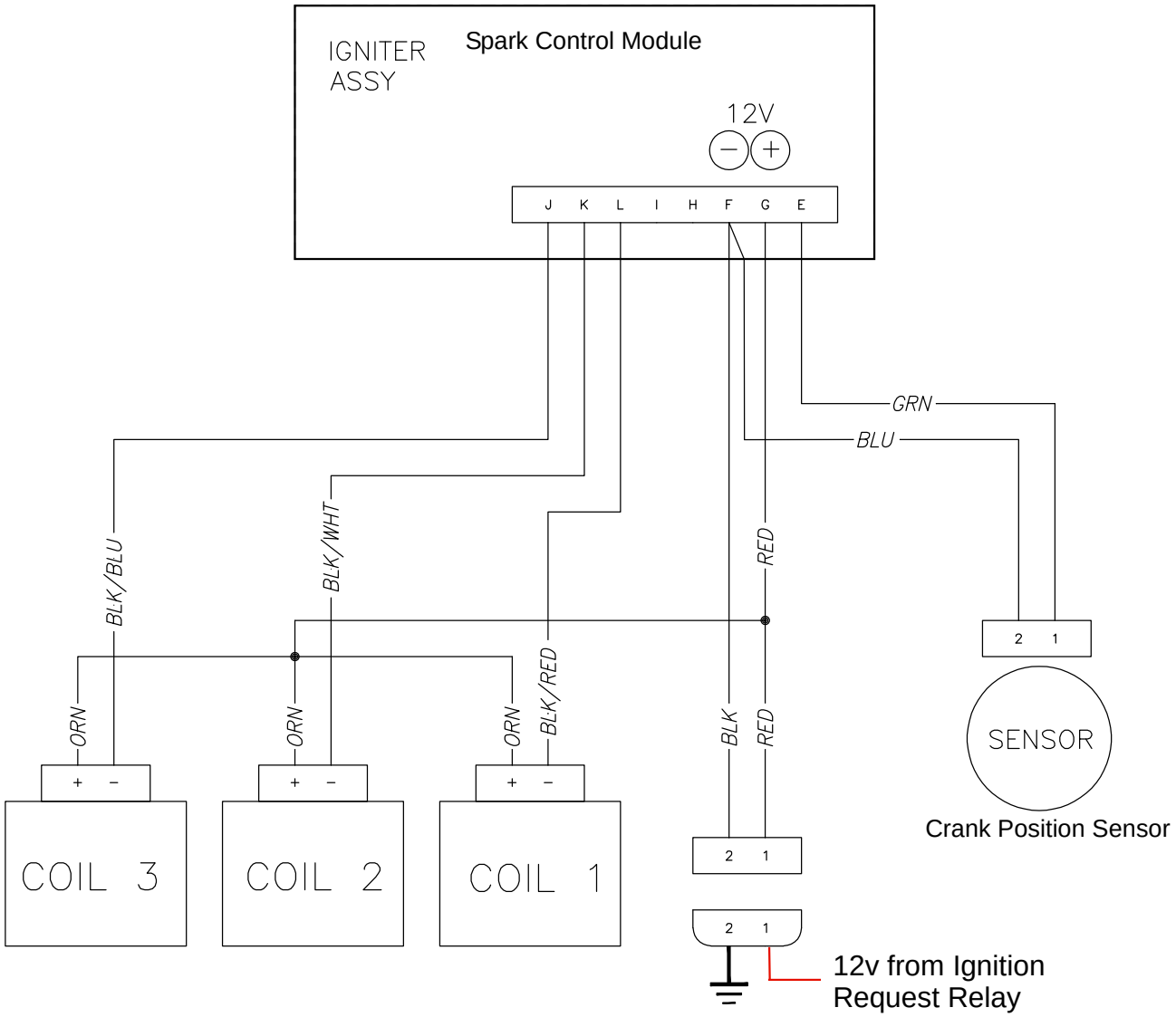
The crank sensor is a two wire " AC pulse generator". It has a wire coil inside of it. As the toothed ring rotates, the teeth pass in line with the end of the sensor tip. This induces a voltage spike that the spark control module can "read" as cylinder position information. The number of spikes per minute is translated as engine RPM. One tooth on the ring is wider than the other five. This creates a unique "spike" so that the spark control module can distinguish the cylinders from one another. This allows it to fire the right ignition coil at the right time. Below is what the crank sensor wave form looks like on an oscilloscope. Notice that every sixth pattern is "wide".



The spark control module is fed power on pin G from the Ignition Request relay. Pin F is connected to ground.

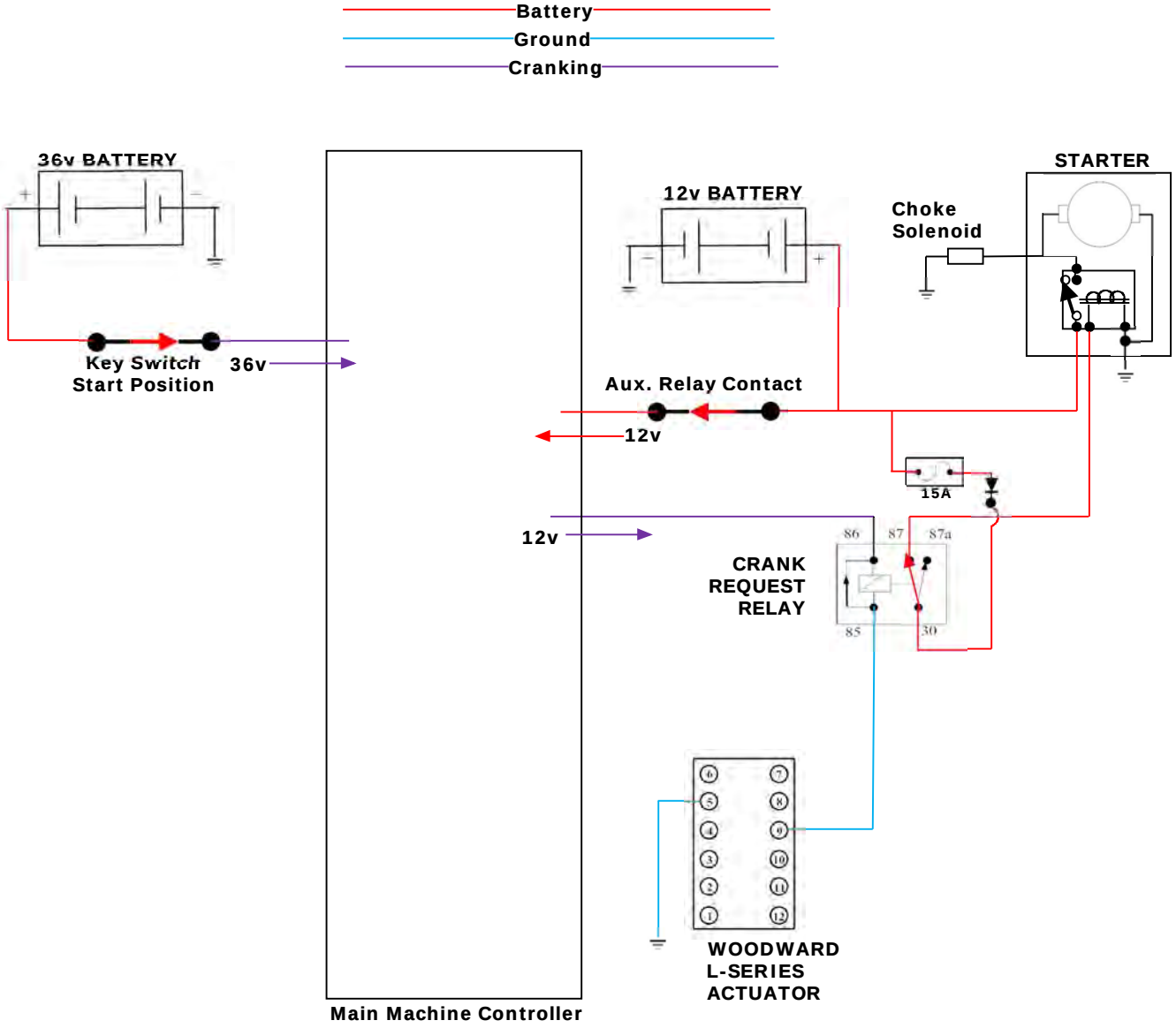
The two wires form the crank position sensor are connected to pins E and F.

All three ignition coils are fed the same power from the ignition request relay. The 12v power supply flows through each coil primary circuit to the spark control unit. The spark control unit supplies a “switched ground” for each of the ignition coil primary windings. When it supplies a ground, current flows through the coil primary winding and builds up a magnetic field around the coil. When the ground is released, the current stops flowing abruptly and the magnetic field collapses. The collapsing magnetic field induces a high voltage in the ignition coil secondary winding which produces a spark across the gap of the spark plug and ignites the air fuel mixture.



Engine Starter and Carburetor Choke Control

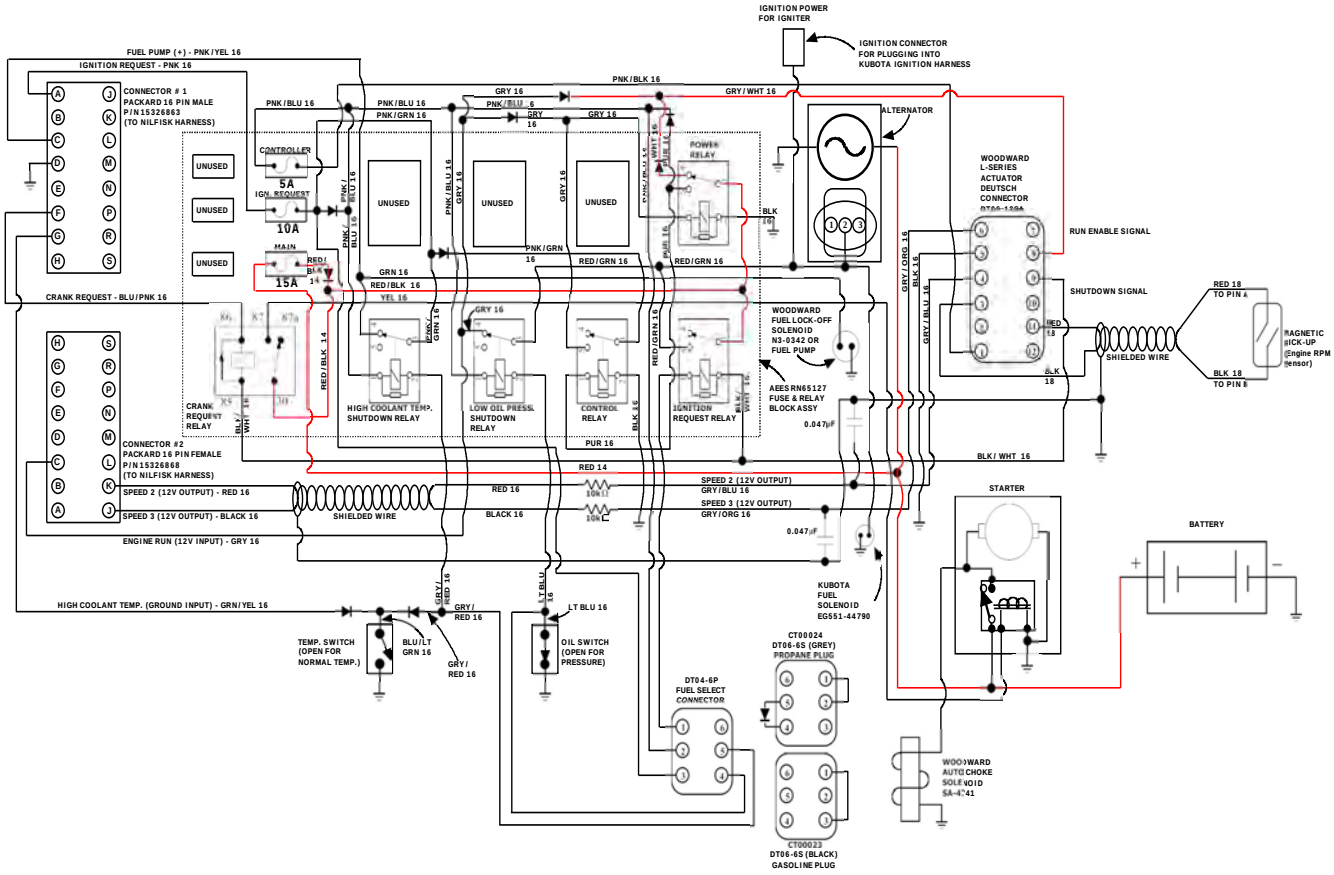
To get the engine starter to engage, the key switch is held in the start position which supplies 36 volts to the main machine controller on the violet wire with the green stripe to connector J7 pin 19. This is the start input request. The main machine controller receives a 12 V supply on connector J3 pin 23 from the engine starter battery. It uses this voltage supply to send 12 volts out of connector J3 pin 10 to the crank request relay coil. The other side of the relay coil is grounded through the Woodward L-series actuator. With power and ground across the relay winding the relay energizes and fused battery power from terminal 30 is sent to the starter solenoid. An electrically operated solenoid pulls the carburetor choke closed when the starter is engaged.



Throttle Control Modes

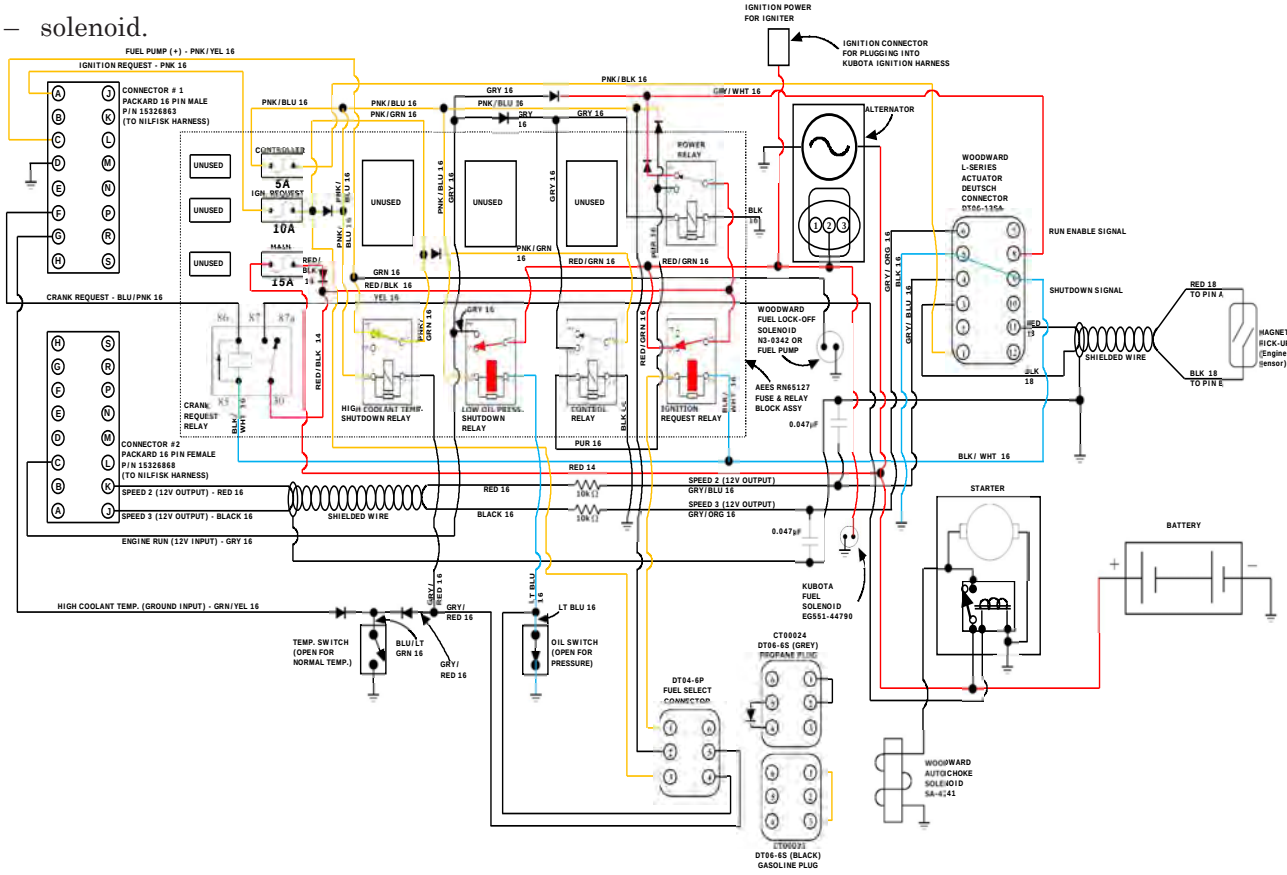
Ignition Off

- Battery power is available through the main fuse to the crank request relay common contact, the ignition request relay common contact and the power relay common contact.
- Battery power is provided to the “run enable” input of the L-Series actuator through the power relay closed at rest contacts. (If it doesn’t have this signal present on power up, it goes into an error mode.)
- There is no power to the ignition system or carburetor fuel shut off solenoid.


IGNITION POWER FOR IGNITER
IGNITION CONNECTOR FOR PLUGGING INTO KUBOTA IGNITION HARNESS
FUEL PUMP (+) - PNK/YEL 16
IGNITION REQUEST - PNK 16
CONNECTOR # 1 PACKARD 16 PIN MALE P/N 15326863 (TO NILFISK HARNESS)
CONTROLLER
5A IGN. REQUEST
10A MAIN
15A
UNUSED
CRANK REQUEST - BLU/PNK 16
CRANK REQUEST RELAY
HIGH COOLANT TEMP. SHUTDOWN RELAY
LOW OIL PRESS. SHUTDOWN RELAY
CONTROL RELAY
IGNITION REQUEST RELAY
POWER RELAY
ALTERNATOR
WOODWARD L-SERIES ACTUATOR DEUTSCH CONNECTOR DTM-12SA
RUN ENABLE SIGNAL
SHUTDOWN SIGNAL
SHIELDED WIRE
MAGNETIC PICK-UP (Engine RPM Sensor)
RED 18 TO PIN 4
BLK 18 TO PIN 8
WOODWARD FUEL LOCK-OFF SOLENOID N3-0342 OR FUEL PUMP
AEESRN65127 FUSE & RELAY BLOCK ASSY
0.047µF
CONNECTOR #2 PACKARD 16 PIN FEMALE P/N 15326868 (TO NILFISK HARNESS)
SPEED 2 (12V OUTPUT) - RED 16
SPEED 3 (12V OUTPUT) - BLACK 16
ENGINE RUN (12V INPUT) - GRY 16
SPEED 2 (12V OUTPUT) GRY/BLU 16
SPEED 3 (12V OUTPUT) GRY/ORG 16
10K Ω
STARTER
BATTERY
KUBOTA FUEL SOLENOID EGS51-44790
HIGH COOLANT TEMP. (GROUND INPUT) - GRN/YEL 16
TEMP. SWITCH (OPEN FOR NORMAL TEMP.)
OIL SWITCH (OPEN FOR PRESSURE)
DT04-6P FUEL SELECT CONNECTOR
CT00024 DT06-6S (GREY) PROPANE PLUG
CT00023 DT06-6S (BLACK) GASOLINE PLUG
WOODWARD AUTOCHOKE SOLENOID 5A-4741

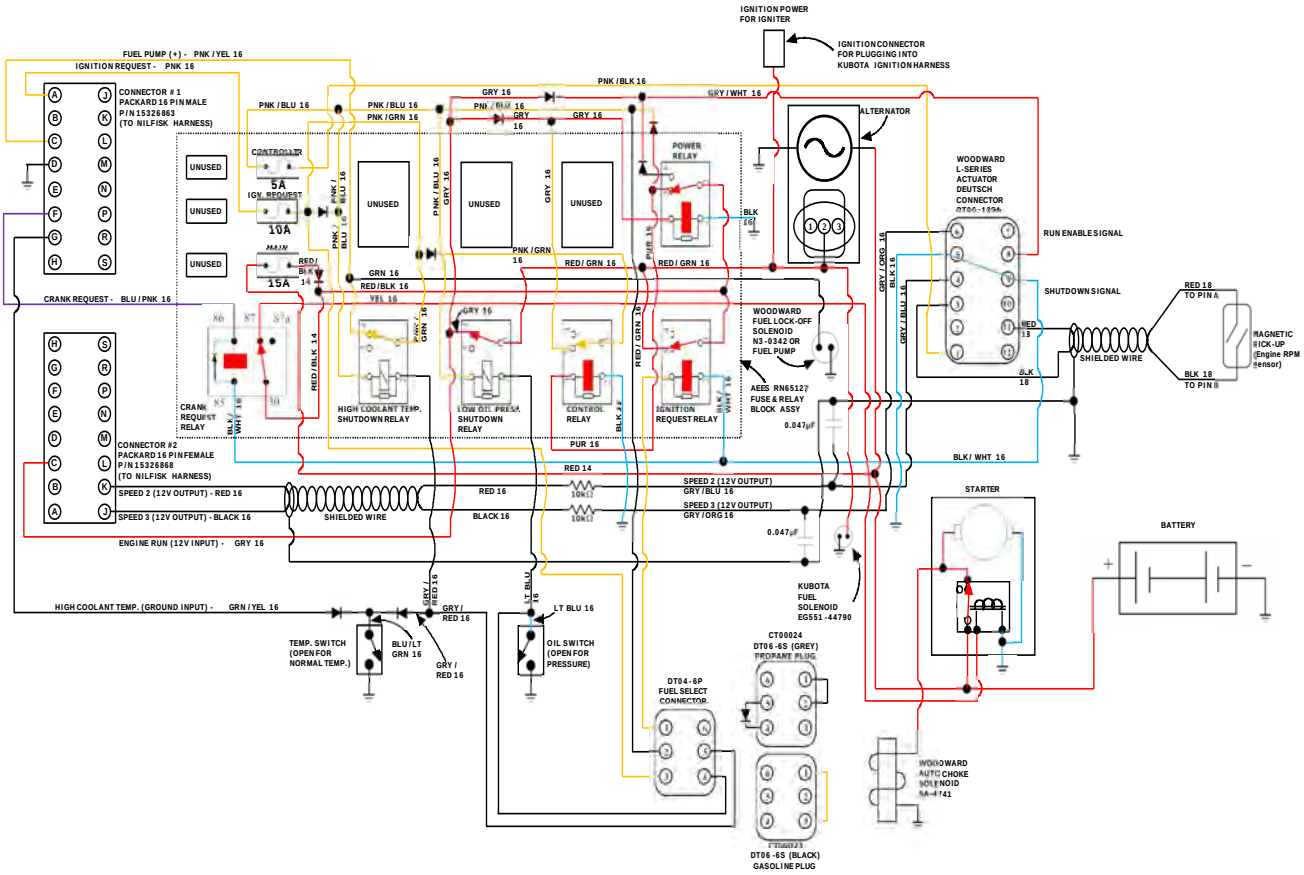
Ignition On

- When the main machine controller sees the key switch input, it sends 12v out on the Ignition Request circuit.
- 12v is provided to the common contact at pin 3 of the high coolant temp. shutdown relay and on through the normally closed contacts to the fuel pump.
- Ignition power is fed to the low oil pressure shut down relay energizing the relay
  - Since there is no oil pressure, the oil pressure switch is closed causing the relay to be energized. This prevents power from being passed to the “engine run” input into the main machine controller.
- 12v passes through the fuel select connector from pin 3 to 1 via the gasoline plug connector to the ignition request relay coil.
- 12v is provided to the actuator pin 1, which wakes it up.
  - The actuator provides a switched path from pin 9 to 5. This provides a ground for the ignition request relay turning it on.
  - The ignition request relay passes battery power to the ignition system, carburetor fuel shut off solenoid and the low oil pressure shutdown relay common contact at pin 3.
  - solenoid.


IGNITION POWER FOR IGNITER
IGNITION CONNECTOR FOR PLUGGING INTO KUBOTA IGNITION HARNESS
FUEL PUMP (+) - PNK/YEL 16
IGNITION REQUEST - PNK 16
CONNECTOR # 1 PACKARD 16 PIN MALE P/N 15326863 (TO NILFISK HARNESS)
ALTERNATOR
WOODWARD L-SERIES ACTUATOR DEUTSCH CONNECTOR DT06-12SA
RUN ENABLE SIGNAL
SHUTDOWN SIGNAL
SHIELDED WIRE
MAGNETIC PICK-UP (Engine RPM sensor)
CRANK REQUEST - BLU/PNK 16
HIGH COOLANT TEMP. SHUTDOWN RELAY
LOW OIL PRESS. SHUTDOWN RELAY
CONTROL RELAY
IGNITION REQUEST RELAY
WOODWARD FUEL LOCK-OFF SOLENOID N3-0342 OR FUEL PUMP
AEES RN65127 FUSE & RELAY BLOCK ASSY
CONNECTOR #2 PACKARD 16 PIN FEMALE P/N 15326868 (TO NILFISK HARNESS)
SPEED 2 (12V OUTPUT) - RED 16
SPEED 3 (12V OUTPUT) - BLACK 16
ENGINE RUN (12V INPUT) - GRY 16
HIGH COOLANT TEMP. (GROUND INPUT) - GRN/YEL 16
TEMP. SWITCH (OPEN FOR NORMAL TEMP.)
OIL SWITCH (OPEN FOR PRESSURE)
KUBOTA FUEL SOLENOID EG551-44790
STARTER
BATTERY
DT04-6P FUEL SELECT CONNECTOR
CT00024 DT06-6S (GREY) PROPANE PLUG
CT00023 DT06-6S (BLACK) GASOLINE PLUG
WOODWARD AUTOCHOKE SOLENOID SA-4141

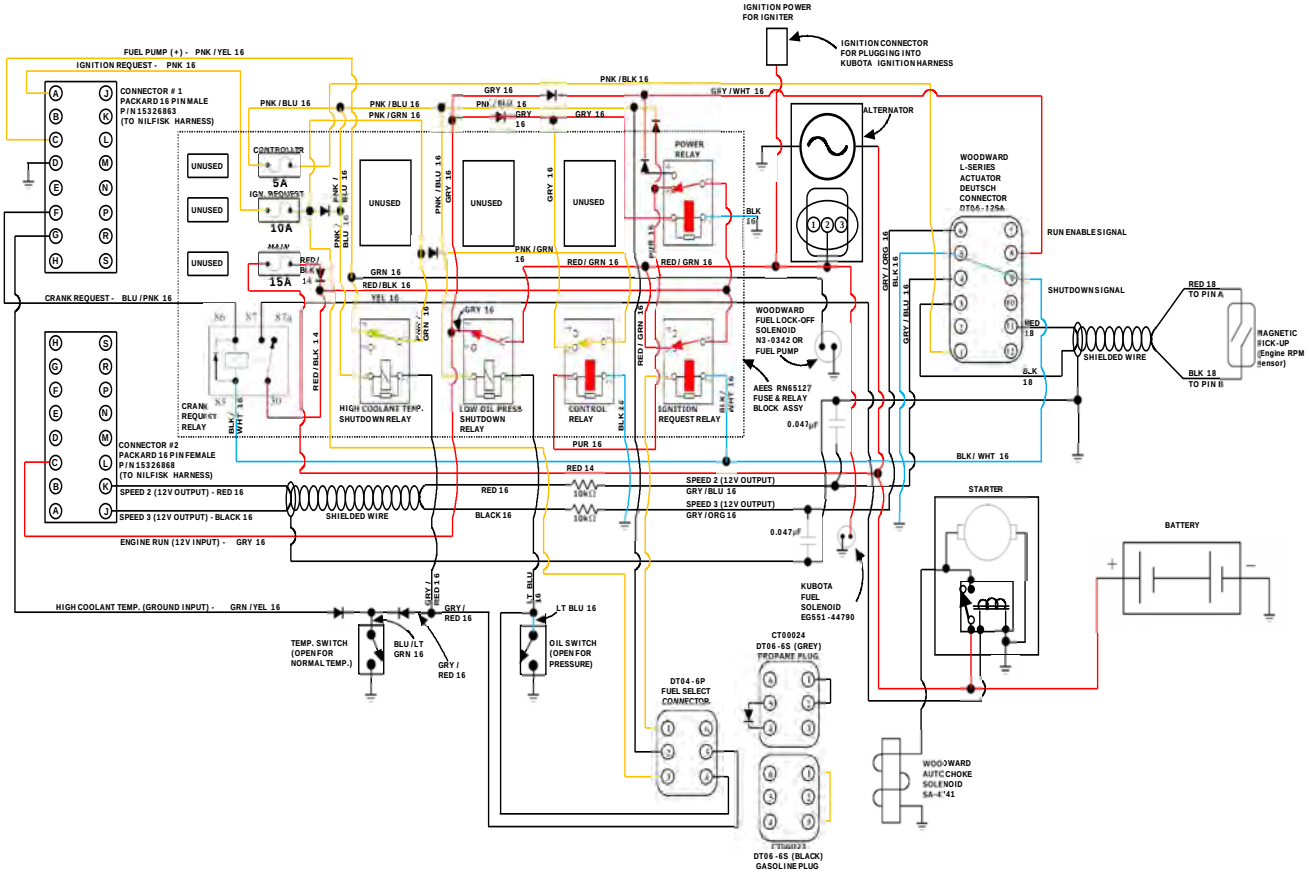
Cranking

- When the main machine controller sees the 36v cranking request from the key switch, it sends out 12v on the crank request circuit to the crank request relay winding. The other side of the winding is grounded through pin 9 of the actuator (as long as there is not a shutdown condition within the L-Series actuator). This energizes the crank request relay and battery power is passed through the contacts to the starter solenoid engaging the starter to turn the engine crankshaft. The starter motor power is also fed to the choke solenoid which pulls the carburetor choke closed.
- Once oil pressure builds up, the oil pressure switch opens.
  - The loss of ground through the oil pressure switch causes the low oil pressure shutdown relay to de-energize.
    - Battery power is then passed through the “closed at rest” contacts to the main machine controller as the “engine run” signal and to the Woodward L series actuator pin 8. From this point on, the “run enable” signal to the actuator is maintained by the low oil pressure shutdown relay.
    - The same power is also passed to the power relay coil energizing the relay.
      - Battery power is then passed through the “closed when energized” contacts of the power relay back into the ignition request circuit and to the control relay winding, energizing the control relay.


IGNITION POWER FOR IGNITER
IGNITION CONNECTOR FOR PLUGGING INTO KUBOTA IGNITION HARNESS
FUEL PUMP (+) - PNK / YEL 16
IGNITION REQUEST - PNK 16
CONNECTOR # 1 PACKARD 16 PIN MALE P/N 15326863 (TO NILFISK HARNESS)
ALTERNATOR
WOODWARD L-SERIES ACTUATOR DEUTSCH CONNECTOR DT06-12SA
RUN ENABLE SIGNAL
SHUTDOWN SIGNAL
SHIELDED WIRE
MAGNETIC PICK-UP (Engine RPM Sensor)
POWER RELAY
UNUSED
CRANK REQUEST - BLU / PNK 16
CRANK REQUEST RELAY
HIGH COOLANT TEMP. SHUTDOWN RELAY
LOW OIL PRESS. SHUTDOWN RELAY
CONTROL RELAY
IGNITION REQUEST RELAY
WOODWARD FUEL LOCK-OFF SOLENOID N3-0342 OR FUEL PUMP
AEES RN65127 FUSE & RELAY BLOCK ASSY
CONNECTOR #2 PACKARD 16 PIN FEMALE P/N 15326868 (TO NILFISK HARNESS)
SPEED 2 (12V OUTPUT) - RED 16
SPEED 3 (12V OUTPUT) - BLACK 16
ENGINE RUN (12V INPUT) - GRY 16
SPEED 2 (12V OUTPUT) GRY / BLU 16
SPEED 3 (12V OUTPUT) GRY / ORG 16
STARTER
BATTERY
KUBOTA FUEL SOLENOID EG551-44790
HIGH COOLANT TEMP. (GROUND INPUT) - GRN / YEL 16
TEMP. SWITCH (OPEN FOR NORMAL TEMP.)
OIL SWITCH (OPEN FOR PRESSURE)
DT04-6P FUEL SELECT CONNECTOR
CT00024 DT06-6S (GREY) PROPANE PLUG
DT06-6S (BLACK) GASOLINE PLUG
WOODWARD AUTO CHOKE SOLENOID 1141

Normal Running

- When the key is released to the “run” position, the main machine controller turns off the voltage to the crank request circuit. This de-energizes the crank request relay and removes power from the starter solenoid.
- The rest of the circuit remains unchanged.


IGNITION POWER FOR IGNITER
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FUEL PUMP (+) - PNK / YEL 16
IGNITION REQUEST - PNK 16
CONNECTOR # 1 PACKARD 16 PIN MALE P/N 15326863 (TO NILFISK HARNESS)
ALTERNATOR
WOODWARD L-SERIES ACTUATOR DEUTSCH CONNECTOR DT06-12SA
RUN ENABLE SIGNAL
SHUTDOWN SIGNAL
SHIELDED WIRE
MAGNETIC PICK-UP (Engine RPM Sensor)
CRANK REQUEST - BLU / PNK 16
CRANK REQUEST RELAY
HIGH COOLANT TEMP. SHUTDOWN RELAY
LOW OIL PRESS SHUTDOWN RELAY
CONTROL RELAY
IGNITION REQUEST RELAY
POWER RELAY
WOODWARD FUEL LOCK-OFF SOLENOID N3-0342 OR FUEL PUMP
AEES RN65127 FUSE & RELAY BLOCK ASSY
CONNECTOR #2 PACKARD 16 PIN FEMALE P/N 15326868 (TO NILFISK HARNESS)
SPEED 2 (12V OUTPUT) - RED 16
SPEED 3 (12V OUTPUT) - BLACK 16
ENGINE RUN (12V INPUT) - GRY 16
HIGH COOLANT TEMP. (GROUND INPUT) - GRN / YEL 16
TEMP. SWITCH (OPEN FOR NORMAL TEMP.)
OIL SWITCH (OPEN FOR PRESSURE)
KUBOTA FUEL SOLENOID EGS51-44790
STARTER
BATTERY
DT04-6P FUEL SELECT CONNECTOR
CT00024 DT06-6S (GREY) PROPANE PLUG
DT06-6S (BLACK) GASOLINE PLUG
WOODWARD AUTOCHOKE SOLENOID SA-4741

Engine RPM Control

The Woodward L-series actuator directly monitors the engine speed sensor input and adjusts the throttle linkage to maintain the current target engine speed. If it is unable to maintain the speed within the desired “window”, it will shut the engine down by removing the path to battery negative for the ignition request relay through the actuator. Note that if the actuator loses the RPM signal while the engine is running, it will shut the engine down. If the actuator never sees an RPM signal, it does not know that the engine is running and has not tried but failed to control the RPM. Therefore it remains in a “cranking mode” and does not shut the engine down.

The main machine controller communicates the desired engine speed mode to the actuator via the Throttle 1 and Throttle 2 wires. It either sends out 0v or 12v on each wire, depending on the desired speed mode.

Speed Mode	Engine Speed	Throttle 1	Throttle 2
Idle	1700 RPM	0	0
Run	2500 RPM	0	12v
Maximum Power	2700 RPM	12v	12v

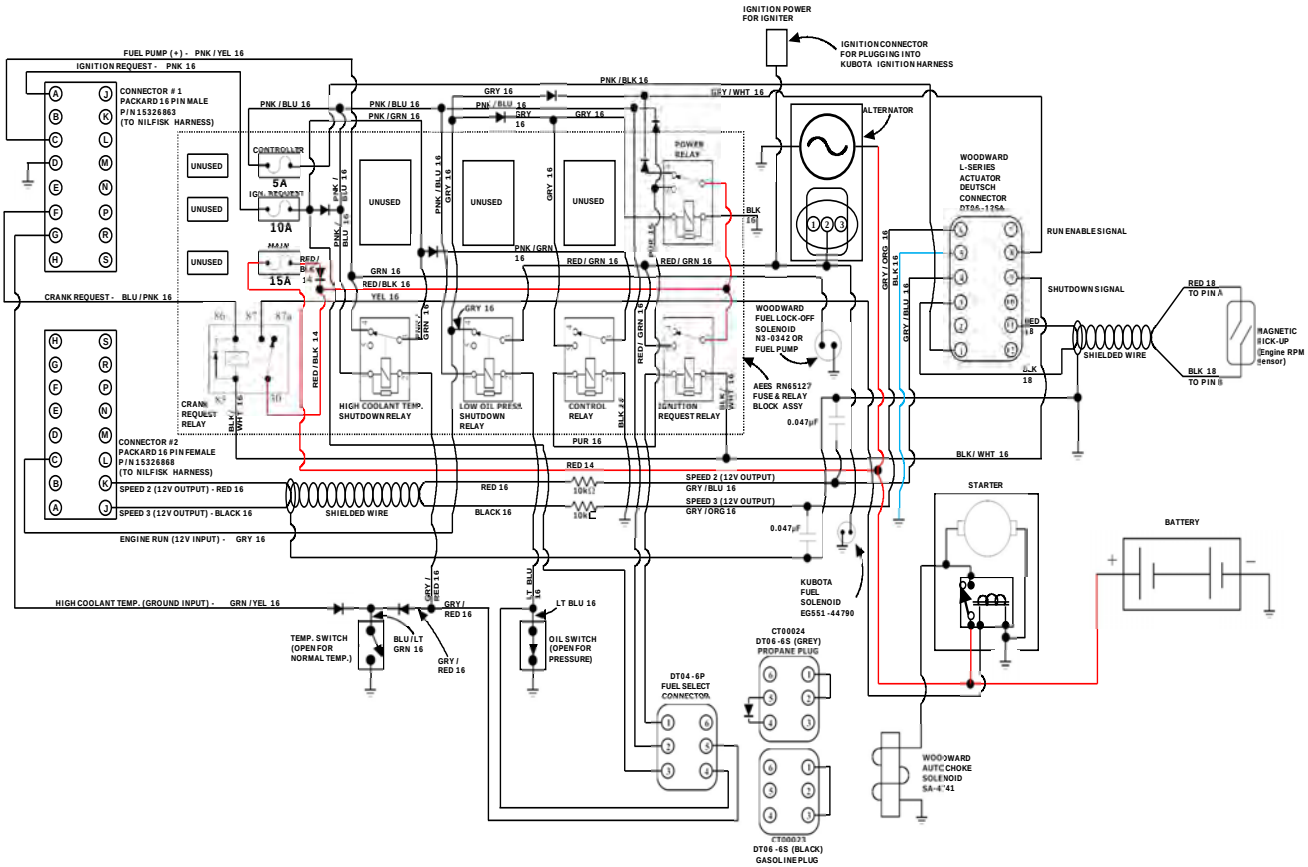
There are several conditions that will override the user's engine speed request.

- High pressure wash forces to run speed.
- If the engine is at idle speed, the engine will be forced to the run speed when sweeping only or vacuuming only. The force idle (neutral time-out) will return the engine to idle speed.
- If the engine is at idle or run speed, the engine will be forced to maximum power speed when scrubbing only or scrubbing and sweeping. The force idle (neutral time-out) will return the engine to idle speed.
- If the override is run speed, the user can change between maximum power speed and run speed.
- If the override condition goes away (e.g. sweep system turns off) and the user has not changed the engine mode, the engine is returned to the mode before the forced override.

Normal Engine Shut Off

When the key switch is shut off, the main machine controller stops sending 12v out the ignition request circuit. This removes the power source for the fuel pump that had been flowing through the "closed at rest" contacts of the high coolant temp shut down relay and from the ignition request relay, which turns it off. Turning off the ignition request relay causes ignition to be immediately lost and the engine to shut off. It also turns off the gasoline shut off solenoid on the carburetor

Several other events also take place. The ignition request power is lost from pin 1 of the Woodward actuator. When this happens, it switches off the path to ground from pin 9 to 5. De-energizing the ignition request relay also results in the loss of the engine run signal through the low oil pressure shut down relay closed at rest contacts, turning off the power relay and control relay


IGNITION POWER FOR IGNITER
IGNITION CONNECTOR FOR PLUGGING INTO KUBOTA IGNITION HARNESS
FUEL PUMP (+) - PNK / YEL 16
IGNITION REQUEST - PNK 16
CONNECTOR # 1 PACKARD 16 PIN MALE P/N 15326863 (TO NILFISK HARNESS)
ALTERNATOR
WOODWARD L-SERIES ACTUATOR DEUTSCH CONNECTOR DT06-16SA
RUN ENABLE SIGNAL
SHUTDOWN SIGNAL
SHIELDED WIRE
MAGNETIC PICK-UP (Engine RPM Sensor)
RED 18 TO PIN A
BLK 18 TO PIN B
UNUSED
CONTROLLER
5A
IGN. REQUEST
10A
MAIN
15A
CRANK REQUEST - BLU / PNK 16
CRANK REQUEST RELAY
HIGH COOLANT TEMP. SHUTDOWN RELAY
LOW OIL PRESS. SHUTDOWN RELAY
CONTROL RELAY
IGNITION REQUEST RELAY
POWER RELAY
WOODWARD FUEL LOCK-OFF SOLENOID N3-0342OR FUEL PUMP
AEES RN65127 FUSE & RELAY BLOCK ASSY
0.047µF
CONNECTOR #2 PACKARD 16 PIN FEMALE P/N 15326868 (TO NILFISK HARNESS)
SPEED 2 (12V OUTPUT) - RED 16
SPEED 3 (12V OUTPUT) - BLACK 16
ENGINE RUN (12V INPUT) - GRY 16
SPEED 2 (12V OUTPUT) GRY / BLU 16
SPEED 3 (12V OUTPUT) GRY / ORG 16
STARTER
BATTERY
KUBOTA FUEL SOLENOID EG551-44790
HIGH COOLANT TEMP. (GROUND INPUT) - GRN / YEL 16
TEMP. SWITCH (OPEN FOR NORMAL TEMP.)
OIL SWITCH (OPEN FOR PRESSURE)
DT04-6P FUEL SELECT CONNECTOR
CT00024 DT06-6S (GREY) PROPANE PLUG
CT00023 DT06-6S (BLACK) GASOLINE PLUG
WOODWARD AUTOCHOKE SOLENOID SA-4741

Engine Protection Modes

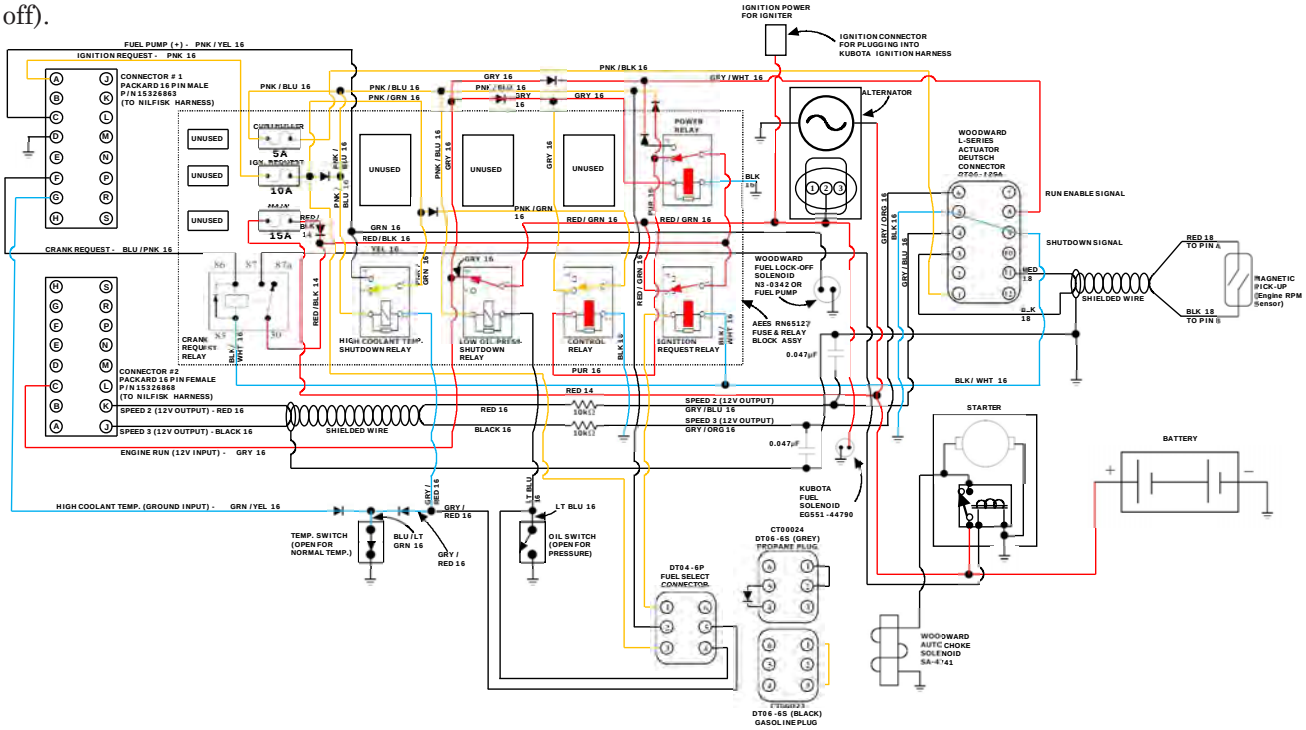
The engine will be shut off in the event that it overheats or loses oil pressure after it has been running. The main machine controller will display a warning message to the operator for either case and will also initiate an engine shut down as a back up measure.

In the case of lost oil pressure, the Woodward L series actuator disables the ignition system by de-energizing the Ignition Request relay.

In the case of the engine overheating, the high coolant temperature shut down relay shuts the engine off by removing power from the fuel pump causing the engine to run out of fuel and stall.

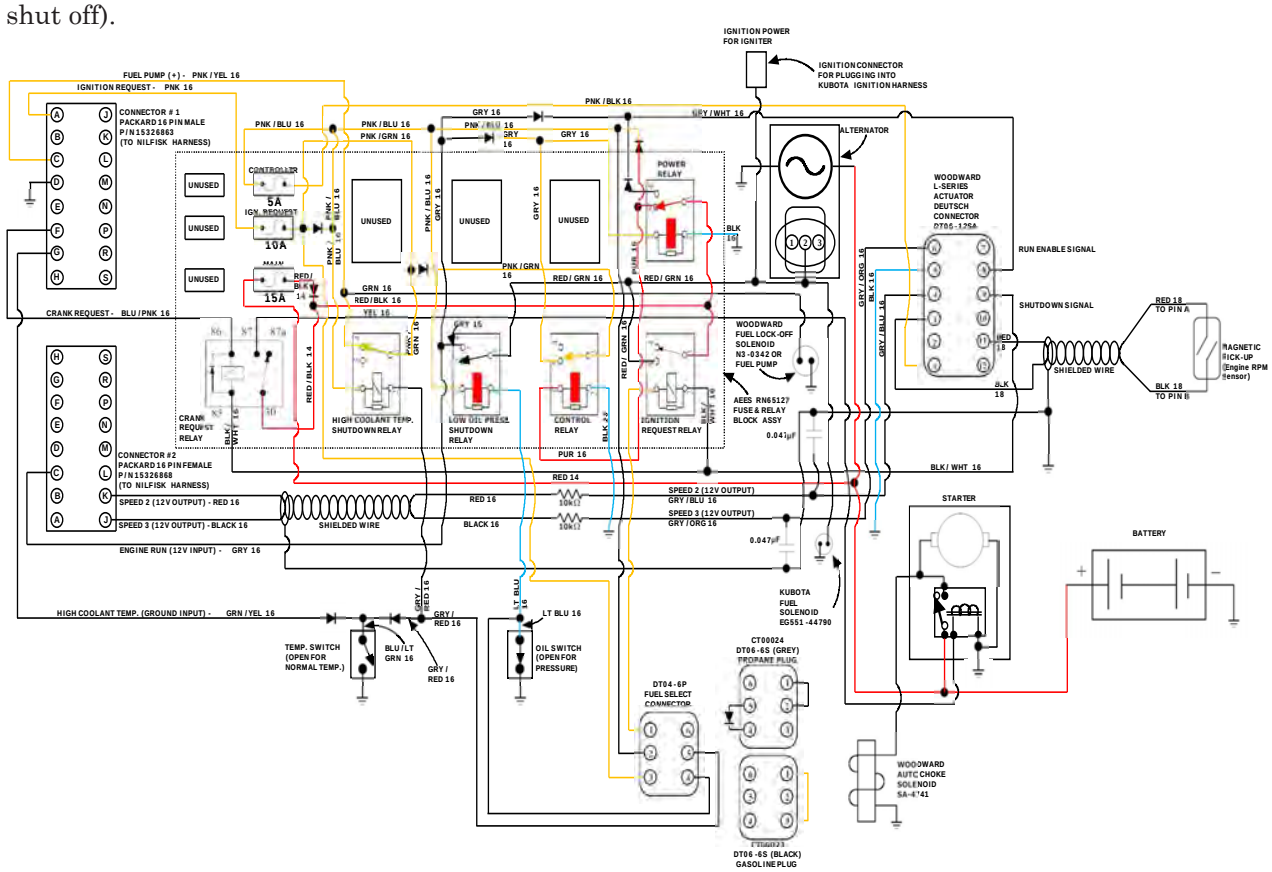
Engine Overheat Shutdown

- If the engine overheats, the temperature switch closes. This completes a path to ground for the high coolant temp shut down relay and energizes the relay. This removes power from the fuel pump. This does not shut the engine down immediately, but allows the engine to use up the fuel in the carburetor float bowl before stalling due to lack of fuel.
- The main machine controller monitors the engine coolant temperature by sending out a 5v feed through an internal resistor to the temperature switch. When the switch closes the voltage on the switch side drops from 5v to 0v . In response, the main machine controller sets an overheat code and alerts the operator. After a 5 second delay, it removes the 12v Ignition request signal. If the engine has not already shut down, the system will then shut down as if the operator had shut off the key (Normal engine shut off).


IGNITION POWER FOR IGNITER
IGNITION CONNECTOR FOR PLUGGING INTO KUBOTA IGNITION HARNESS
ALTERNATOR
FUEL PUMP (+) - PNK / YEL 16
IGNITION REQUEST - PNK 16
CONNECTOR # 1 PACKARD 16 PIN MALE P/N 15326863 (TO NILFISK HARNESS)
UNUSED
5A
10A
15A
POWER RELAY
WOODWARD L-SERIES ACTUATOR DEUTSCH CONNECTOR
RUN ENABLE SIGNAL
SHUTDOWN SIGNAL
CRANK REQUEST - BLU /PNK 16
CRANK REQUEST RELAY
HIGH COOLANT TEMP. SHUTDOWN RELAY
LOW OIL PRESS. SHUTDOWN RELAY
CONTROL RELAY
IGNITION REQUEST RELAY
WOODWARD FUEL LOCK-OFF SOLENOID N3-0342 OR FUEL PUMP
AEES RN6512? FUSE & RELAY BLOCK ASSY
0.047µF
SHIELDED WIRE
MAGNETIC PICK-UP (Engine RPM Sensor)
CONNECTOR #2 PACKARD 16 PIN FEMALE P/N 15326868 (TO NILFISK HARNESS)
SPEED 2 (12V OUTPUT) - RED 16
SPEED 3 (12V OUTPUT) - BLACK 16
ENGINE RUN (12V INPUT) - GRY 16
SPEED 2 (12V OUTPUT) GRY/BLU 16
SPEED 3 (12V OUTPUT) GRY/ORG 16
STARTER
BATTERY
KUBOTA FUEL SOLENOID E0551-44790
HIGH COOLANT TEMP. (GROUND INPUT) - GRN /YEL 16
TEMP. SWITCH (OPEN FOR NORMAL TEMP.)
OIL SWITCH (OPEN FOR PRESSURE)
DT04-6P FUEL SELECT CONNECTOR
CT00024 DT06-6S (GREY) PROPANE PLUG
DT06-6S (BLACK) GASOLINE PLUG
WOODWARD AUTC CHOKE SOLENOID SA-4741

Lost Oil Pressure Shutdown

- If the engine oil pressure is lost, the oil pressure switch will close causing the low oil pressure shut down relay to energize taking power away from the “closed at rest” contact. This removes the power from the run enable signal to pin 8 of the Woodward L series actuator. The actuator immediately switches off the internal ground for the shut down control circuit at pin 9 causing the ignition request relay to de-energize. This shuts down the ignition system and the carburetor fuel shut off solenoid causing the engine to stall immediately. Note that the power relay remains “latched-on” due to ignition voltage supplied by the control relay.
- When the low oil pressure shut down relay energizes, power is also lost for the engine run signal to the main machine controller. The loss of the engine run signal is interpreted as “loss of oil pressure” by the main machine controller. It responds by immediately displaying an engine warning message to the operator and removing the 12v power going out to the ignition request circuit. If the engine has not already shut down, the system will then shut down as if the operator had shut off the key (Normal engine shut off).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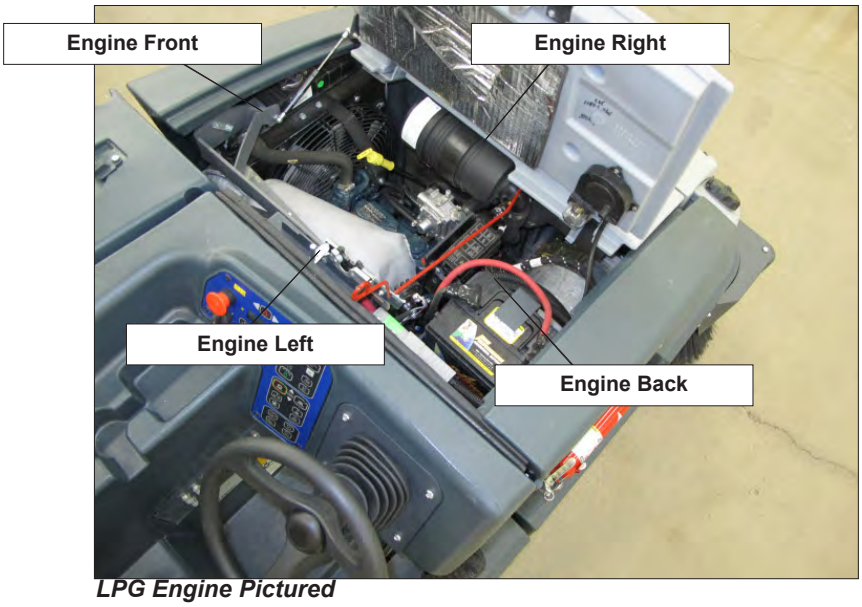
FUEL PUMP (+) - PNK / YEL 16
IGNITION REQUEST - PNK 16
CONNECTOR # 1 PACKARD 16 PIN MALE P/N 15326863 (TO NILFISK HARNESS)
ALTERNATOR
POWER RELAY
WOODWARD L-SERIES ACTUATOR DEUTSCH CONNECTOR DT06-12SA
RUN ENABLE SIGNAL
SHUTDOWN SIGNAL
CRANK REQUEST - BLU / PNK 16
CRANK REQUEST RELAY
HIGH COOLANT TEMP. SHUTDOWN RELAY
LOW OIL PRESS SHUTDOWN RELAY
CONTROL RELAY
IGNITION REQUEST RELAY
WOODWARD FUEL LOCK-OFF SOLENOID N3-0342 OR FUEL PUMP
AEES RN6512? FUSE & RELAY BLOCK ASSY
SHIELDED WIRE
MAGNETIC PICK-UP (Engine RPM sensor)
CONNECTOR #2 PACKARD 16 PIN FEMALE P/N 15326868 (TO NILFISK HARNESS)
SPEED 2 (12V OUTPUT) - RED 16
SPEED 3 (12V OUTPUT) - BLACK 16
ENGINE RUN (12V INPUT) - GRY 16
STARTER
BATTERY
HIGH COOLANT TEMP. (GROUND INPUT) - GRN / YEL 16
TEMP. SWITCH (OPEN FOR NORMAL TEMP.)
OIL SWITCH (OPEN FOR PRESSURE)
KUBOTA FUEL SOLENOID EG551-44790
DT04-6P FUEL SELECT CONNECTOR
CT00024 DT06-6S (GREY) PROPANE PLUG
WOODWARD AUTC CHOKE SOLENOID SA-4741
DT06-6S (BLACK) GASOLINE PLUG

Note: If the engine stalls due to loss of fuel or ignition, oil pressure will eventually be lost. When this happens the main machine controller will treat it as a lost oil pressure condition, display a warning message to the machine operator and initiate the lost oil pressure shut down sequence.

Component Locations

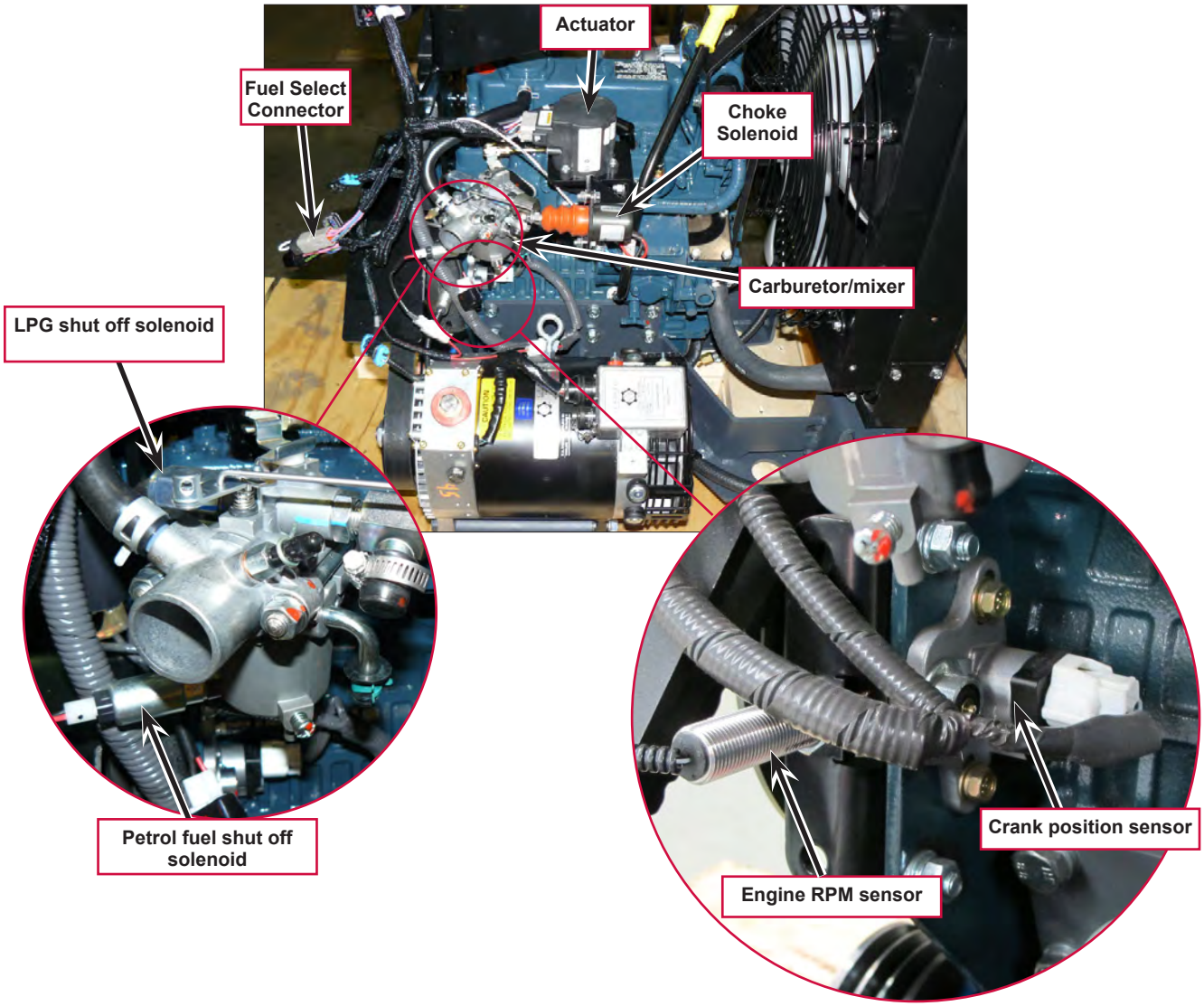
Engine components are grouped according to the area of the engine. They are photographed on an engine that is not installed in the machine for better visibility.



LPG Engine Pictured

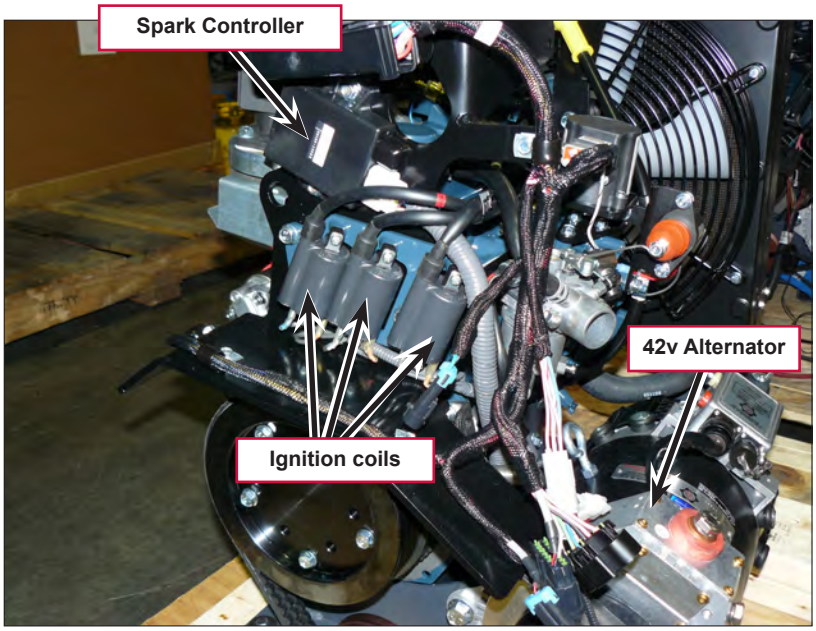
Engine Right Side View (Toward front of machine)

- Actuator
- Choke Solenoid
- Carburetor/mixer
- Engine RPM sensor
- Crank position sensor
- Petrol fuel shut off solenoid
- Fuel Select Connector



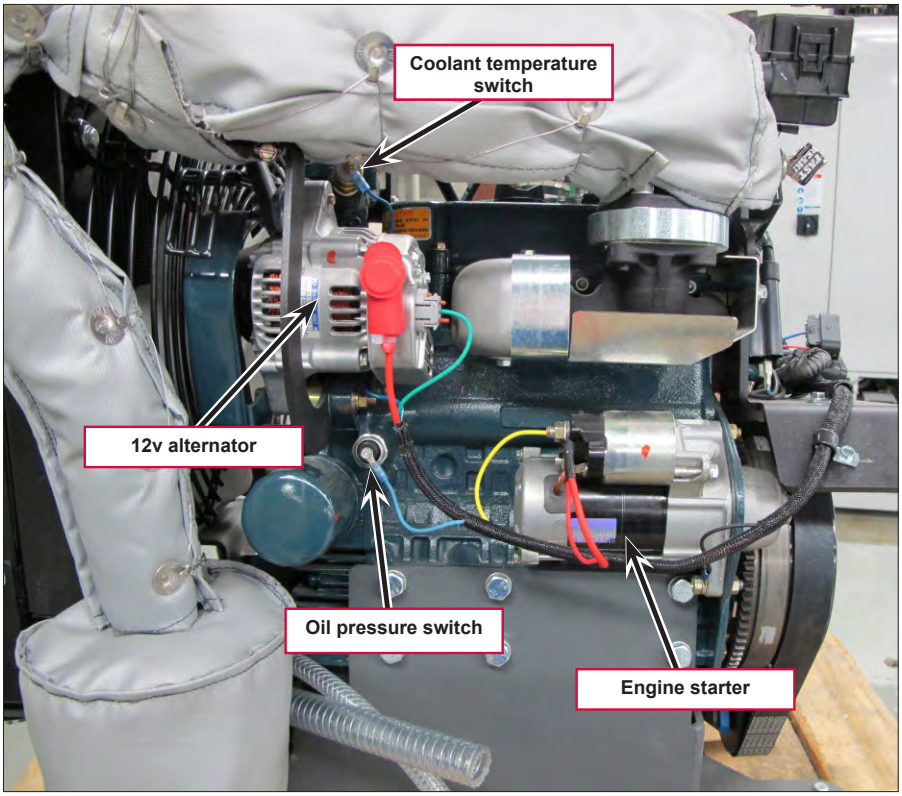
Engine Back Side View (Toward right of machine)

- Spark Controller
- 42 V Alternator
- Ignition coils



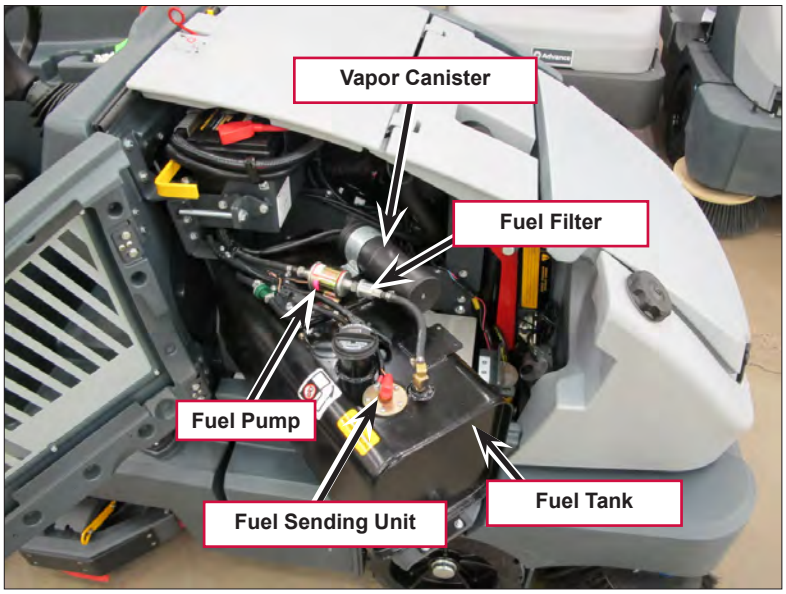
Engine Left *Side View (Toward back of machine)*

- 12 V alternator
- Engine starter
- Oil pressure switch
- Coolant temperature switch



Fuel Tank Area

- Fuel tank
- Fuel Pump
- Fuel Filter
- Fuel Sending Unit
- Vapor Canister



Maintenance and Adjustments

Maintenance Checklist

This check list is courtesy of the Kubota Gasoline, LPG, engine Workshop Manual. See the workshop manual for more details on performing these operations.

Daily:

- Check engine oil level
- Check and replenish coolant
- Check air cleaner element

First 50 hours:

- Change engine oil
- Replace engine oil filter

Every 50 hours

- Clean air cleaner element
- Check fuel hoses and clamps

Every 100 hours

- Clean spark plug
- Check fuel filter
- Check fan belt tension and damage

Every 200 hours

- Change engine oil
- Replace engine oil filter
- Check radiator hoses and clamp bands

Every 1 year

- Replace air cleaner element
- Replace gasoline fuel hose, clamp bands and fuel filter
- Clean fuel tank inside
- Clean water jacket and radiator interior

Every 1000 hours

- Replace spark plug
- Check valve clearance

- Clean combustion chamber if necessary

Every 2 years

- Replace intake air line
- Replace breather hose
- Replace radiator hoses and clamp bands
- Replace battery
- Replacing ignition wires
- Change radiator coolant (L.L.C.)

Change Engine Oil and Oil Filter

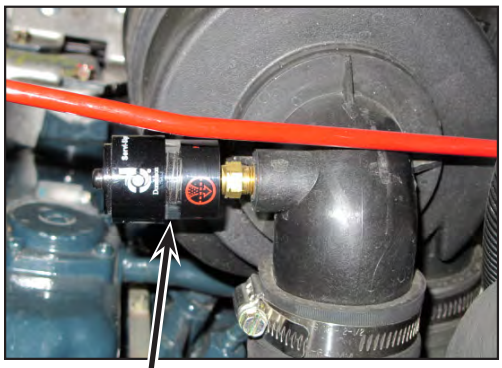
1. Drain the recovery tank for later removal.
2. Shut off the engine and allow it to cool sufficiently to avoid burning yourself with hot engine oil.
3. Remove the left side engine cover.
4. Tip the recovery tank outward. Release the recovery tank tether cable and recover hose, then lower the recovery tank to the ground for better access to the engine oil filter area.
5. Remove the oil filter with an oil filter wrench.
6. Apply a light coat of engine oil to the new filter cartridge gasket.
7. Screw the new cartridge on and tighten by hand. Over tightening may damage the gasket.
8. Remove the remote oil drain hose end from the radiator bracket.
9. Remove the plug and drain the oil into a suitable container.
10. Reinstall the plug-and reattach the drain hose to the radiator bracket.
11. Refill the engine with oil.

Change Engine Coolant

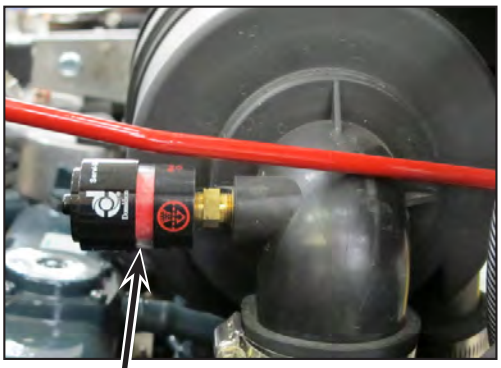
1. Allow the engine to cool sufficiently to relieve cooling system pressure and avoid burns.
2. Remove the left side engine cover.
3. Remove the radiator cap.
4. Locate the remote engine coolant drain hose, remove the plug and direct the coolant into a suitable container.
5. Reinstall the drain plug and reposition the drain hose.
6. Refill with a 50/50 mixture of engine antifreeze and water.

Inspect Air Filter

Check the service indicator mounted on the air cleaner elbow. If the red disc is visible in the “window”, the filters should be cleaned or replaced.



Clear Window = Okay



Red in Window = Restricted Filters

Replace Air Filters

1. Release the latches and remove the air filter housing cover.
2. Remove the outer filter element.
3. Blow out air cleaner housing with compressed air with inner filter element still in place to prevent dirt from entering the engine air intake.
4. Remove the inner filter element.
5. Clean residual dust from the inside of the air cleaner housing, taking care to prevent any dirt or debris from entering the air intake.
6. Install a new inner filter element and then the new outer filter element making sure that they seal well at their ends.
7. Install the air cleaner housing cover.

Troubleshooting

Checking Spark

1. Remove the spark plug wire from the spark plug and insert an adjustable KV tester in the end of the wire.
2. Adjust the gap to approximately 20 - 30 KV and clip the tester to a good ground on the engine.
3. Crank the engine over and check for consistent arcing across the tester gap.

No crank - The starter does not engage

Possible causes:

- 36v battery pack drained (preventing main machine controller from powering up.)
- Engine Battery
- Starter
- Battery to starter cable
- Engine Ground
- No voltage to the starter solenoid
  - Open circuit breaker CB9
  - Auxiliary Relay
    - Burned contacts or not energized
  - Key Switch
  - Main Machine Controller
  - Woodward L Series Actuator (Not supplying ground for crank request relay)
  - Crank request relay
- Wiring

Cranks but does not start – No Spark

Possible causes:

- Spark Control Module not powered up.
  - Ignition request relay
  - Woodward L Series Actuator not energizing ignition request relay
  - Spark control module ground
- Crank Position Sensor
- Spark Control Module
- Wiring
- Ignition Coils (not likely that all 3 coils would fail at once)

Cranks but does not start (has sufficient spark)

Possible causes:

- No fuel
  - Empty tank
  - Fuel pump inoperative
  - No electrical power to fuel pump
    - Ignition request fuse – blown
    - High coolant temp shut down relay – “Closed at rest” contacts not making connection
    - Open wire on positive or negative side of fuel pump
  - No power to carburetor petrol fuel shut off solenoid
- Mechanical engine
  - Insufficient compression
  - Plugged Intake
  - Plugged Exhaust
- Actuator
  - Not opening throttle

Achieves one but not ALL RPM modes.

The approach to diagnosing an engine RPM control problem is to check the inputs to the L series actuator. If the inputs are good and the output is bad, the conclusion is that the actuator is the problem. However, don't forget that insufficient fuel supply or a restricted exhaust could appear like an RPM control problem if the engine cannot run well enough to achieve a higher RPM.

Possible Causes:

- Failed Engine Speed Sensor
- Actuator linkage
- Actuator power supply
- Actuator
- Wiring
- Main Machine Controller

Diagnostic steps

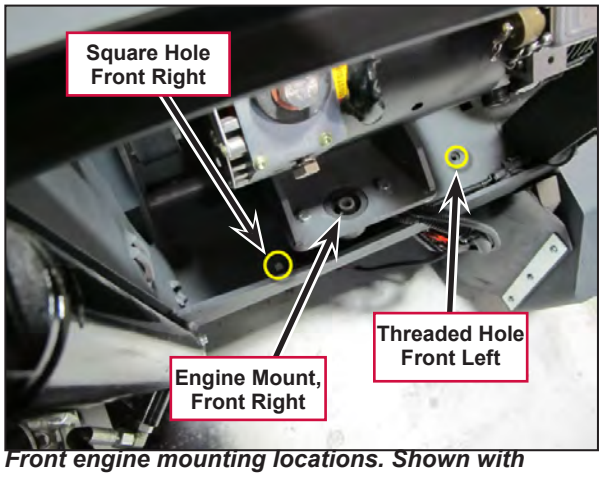
1. Visually inspect the linkage between the actuator arm and the carburetor throttle lever.
   - Is the linkage okay?
     - If not, repair
     - If so, go to next step.
2. Check the power and ground supplies to the actuator.
   - Is there sufficient power and ground?
     - If so, go on to check the Engine RPM Sensor input.
     - If not, repair.
3. Check the Engine RPM Sensor input. (Check the AC voltage while the engine is running or check resistance of sensor through wiring harness from the actuator connector.)
   - Is the Engine RPM sensor input okay?
     - If so, go on to check the speed request inputs.
     - If not, repair.
4. Check the speed request inputs - With the engine running press the engine speed button and check for 12v to the throttle 1 wire at the actuator.
   - Is 12v present on the throttle 1 wire?
     - If so, replace the actuator
     - If not, check the wiring between the main machine controller and the governor controller.
     - If the wiring is okay, check the output coming out of the main machine controller.

Removal and Installation

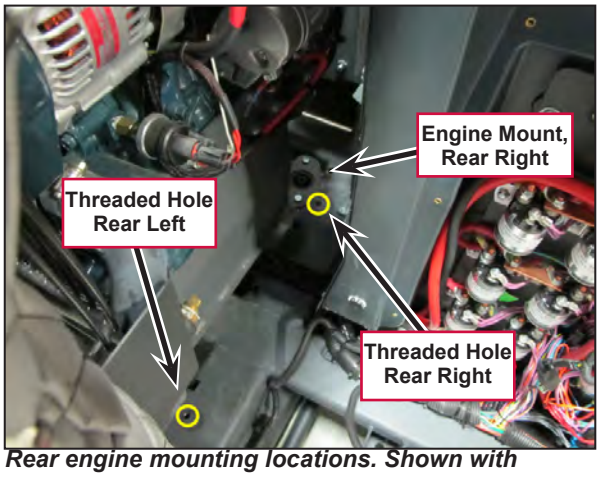
Engine Assembly

The complete engine including the exhaust, radiator and 42v alternator are removed as an assembly. There is no need to drain engine oil or coolant. The assembly is attached to the chassis at 4 rubber motor mounts. The front right mount has a square hole in the chassis for a carriage bolt. The other 3 are threaded holes in the frame.

1. Remove engine Top cover
2. Disconnect the 36v battery pack main positive and negative cables.
3. Disconnect the 12v battery negative cable.
4. Disconnect the 12v battery positive cable.
5. Disconnect fuel supply and return lines.
6. Disconnect battery positive and negative cables at the starter.
7. Disconnect the engine wiring connectors.
8. Remove the 4 motor mount fasteners. (Note: photos are of diesel engine)



Front engine mounting locations. Shown with hopper up and engine being installed.



Rear engine mounting locations. Shown with engine being installed.

9. Lift the assembly out of the chassis using a suitable hoist attached to the two engine lift points.
10. Reassemble in reverse order. Connect the battery negative cables last.

Specifications

Engine Oil

Engine oil capacity - 3.4 L, 0.90 U.S.gals

- IMPORTANT
  - When using an oil of different maker or viscosity from the previous one, remove all of the old oil.
  - Never mix two different types of oil.
  - Engine oil should have properties of API classification SH or better.
  - Use the proper SAE Engine Oil according to ambient temperature.
    - Above 25 °C (77 °F) - SAE30 or SAE10W-30
    - 0 °C to 25 °C (32 °F to 77 °F) - SAE20 or SAE10W-30
    - Below 0 °C (32 °F) - SAE10W or SAE10W-30

Engine Coolant

Use only ethylene glycol or propylene glycol type anti-freeze for this engine. Always assure a 50% / 50% anti-freeze and water mixture regardless of temperature.

Shop Measurements

The following information provides some “real world” shop measurements to help you recognize what “normal” looks like.

Ignition System

Ignition coil primary resistance – 2.15 ohms

Ignition coil secondary resistance – 18.4 K ohms

Spark Output - 30 KV consistently (Using adjustable spark tester)

Crank position sensor resistance - 2.18 K ohms

Crank position sensor output cranking - 1.1 VAC average. 2.0 VAC RMS

Crank position sensor output running - 5.5 VAC average

Spark Controller Measurements:

Pin Letter	Wire Color on machine	Circuit	Voltage with key on unplugged
E	BLU	Crank Position Sensor	0v
F	BLK	Ground (And other leg of Crank sensor)	0.004v
G	Red	Power Supply	11.2v
H	Not used		
I	Not used		
J	BLU/BLK	Coil 3 Driver	11.2v
K	WHT/BLK	Coil 2 Driver	11.2v
L	RED/BLK	Coil 1 Driver	11.2v

Governor Control System

Woodward L Series Actuator Measurements

Pin	Wire Color	Circuit Description	Connector Unplugged Key On	Connector Plugged In Key On
1	PNK/BLK	Ignition Request	11.69v	11.4v
2	Not used			
3	BLK	Engine RPM Sensor	-	-
4	GRA/BLU	Throttle 2	7.79v	0.007v
5	BLK	Ground	0.007v	0.007v
6	GRA/ORN	Throttle 1	7.78v	0.007v
7	Not used			
8	GRA/WHT	Run Enable Signal	11.9v	11.0v
9	BLK/WHT	Shut Down Signal	11.6v	0.028v
10	Not Used			
11	CLR	Engine RPM Sensor	-	-
12	Not Used			

RPM Sensor Output (measured at the actuator Pin 3 and 11 with the connector plugged in):

- 0.68v AC when cranking
- 2.13v AC when running

Engine RPM sensor resistance - 2.07 K ohms

Fuel System

Fuel Pressure - 3.5-4.0 PSI (24-27 Kpa)

Fuel volume - 0.5L in 15 seconds

Carburetor Fuel Shut-off Solenoid resistance - 38 ohms

Electric Choke Solenoid resistance - 2.5 ohms

Engine

Engine Vacuum at idle - approx 17.5 inches HG (59 Kpa)

When returning from low RPM to idle vacuum momentarily peaks around 21” HG

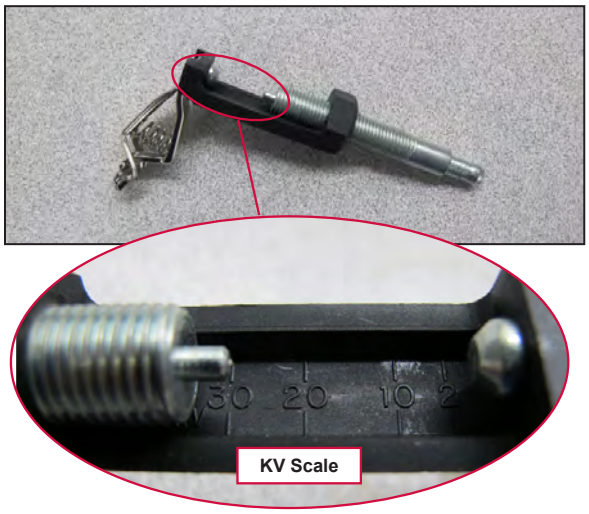
Engine Compression

- Cyl #1 - 170 PSI
- Cyl #2 - 170 PSI
- Cyl #3 - 170 PSI

Special Tools

Adjustable KV Spark Tester.

Most automotive parts suppliers sell these tools. Shown is 50850 from Lisle corporation. http://www.lislecorp.com/



Hopper System

Functional Description

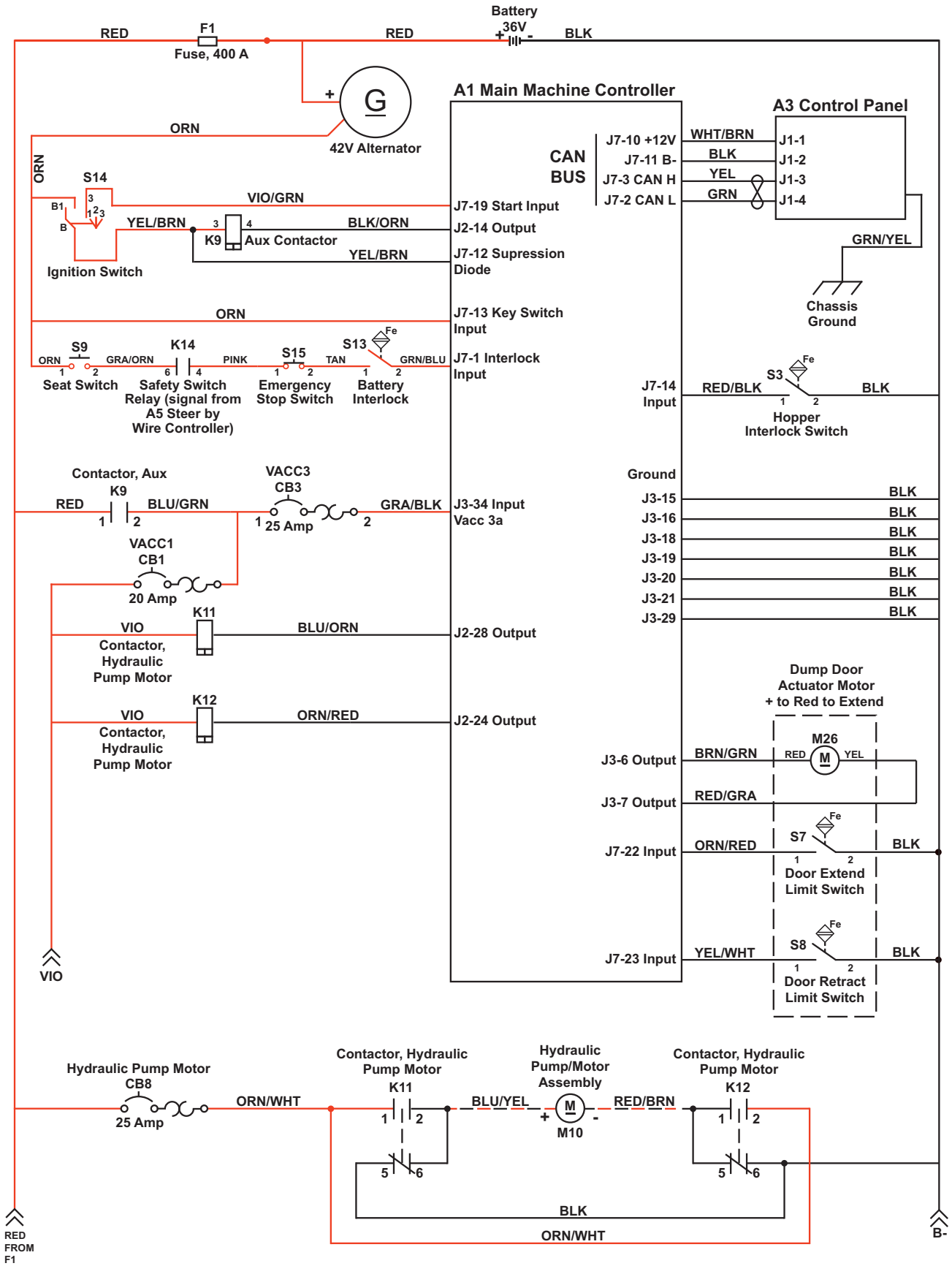
Overview

The hopper system holds the dirt, dust and debris swept up by the brooms. The hydraulic lift cylinder raises the hopper to allow the accumulated dirt and debris to be dumped into a suitable receptacle, then lowers the hopper back down into the normal operating position. The hopper lift cylinder is powered by a separate hydraulic power pack that includes an electric motor and hydraulic pump. Two double pole contactors control the lift cylinder direction by reversing the polarity to the pump motor.

The hopper dump door, driven by an electric actuator, can be opened by pressing the hopper door open button when the hopper is up to empty the hopper. Proximity sensors limit the hopper dump door actuator travel. Note that the hopper door opens automatically to receive the dirt and debris from the brooms when the hopper is in the operating position and the sweep system is enabled. Once the sweep system is switched off, the hopper door closes. An interlock prevents the hopper door from being opened manually if the hopper is down.

The hopper interlock proximity sensor signals the A1 Main Machine Controller when the hopper is closed.

Hopper System Wiring Diagram

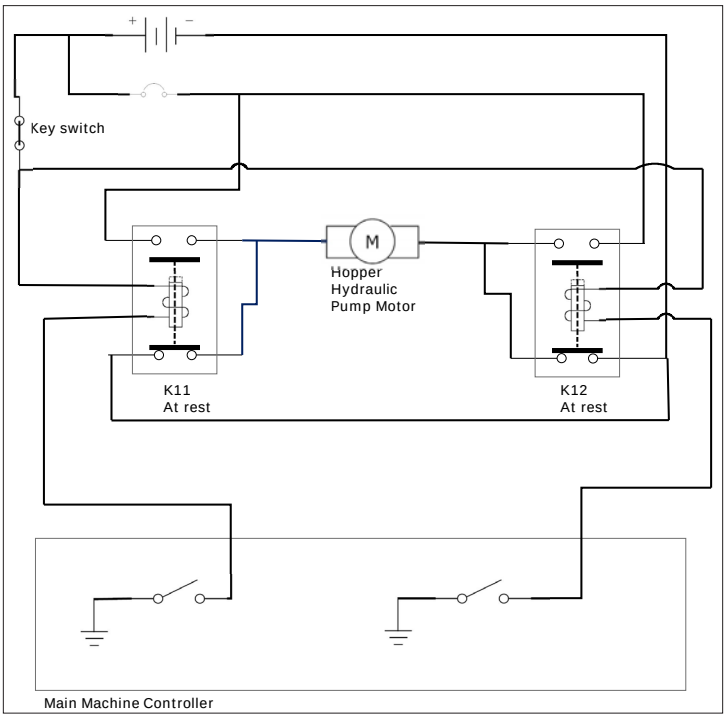


Hopper Hydraulic System Circuit Details

A hydraulic cylinder (ram), driven by a self-contained hydraulic pump and motor, raises and lowers the hopper. The pump motor power and ground polarity are reversed to make the motor run in opposite directions. Two contactors (**K11** and **K12**) are used to operate the pump. Each contactor has two sets of contacts; one that is closed when at rest (normally closed) and one that is open (normally open) when at rest.

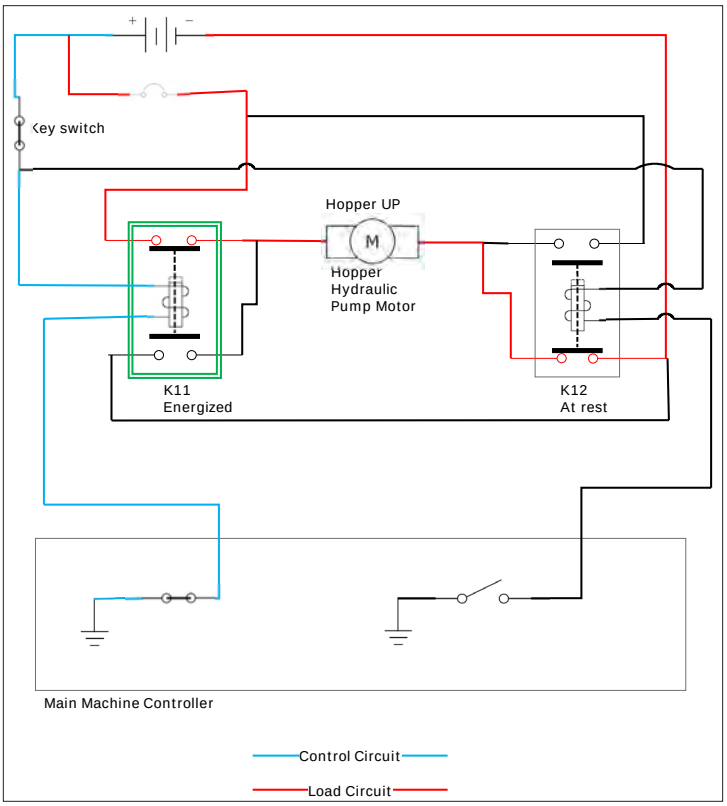
Hopper at Rest

When the hopper is “at rest”, the normally-closed contacts of each contactor connect both sides of the hopper hydraulic pump motor to battery negative. Since there is no difference in electrical pressure (voltage) across the pump, no current flows and the pump remains “Off”.



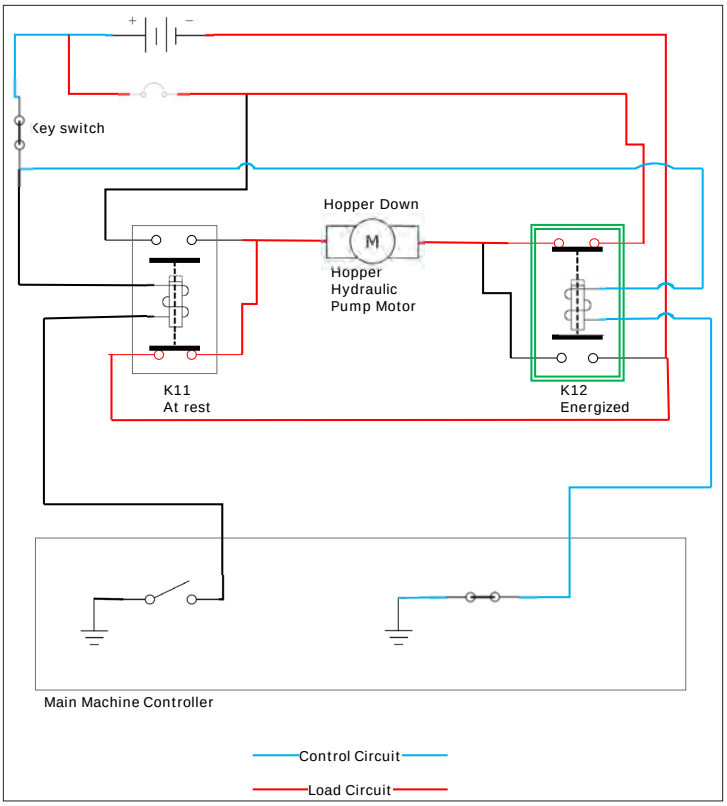
Hopper Being Raised

When the operator pushes the button to raise the hopper, the main machine controller energizes the **K11** contactor by grounding the control winding of the contactor. This causes a magnetic field to pull the normally-closed contacts open, and at the same time closes the normally-open contacts. Battery voltage is now applied through the closed set of **K11** contacts to one side of the pump. The other side of the pump is connected to battery negative through the normally-closed contacts of the **K12** contactor. This completes the circuit and causes the pump to run in the “Up” direction.



Hopper Being Lowered

When the operator pushes the button to lower the hopper, the main machine controller energizes the **K12** contactor by grounding the control winding of the contactor. This causes a magnetic field to pull the normally-closed contacts open, and at the same time closes the normally-open contacts. Battery voltage is now applied through the closed set of **K12** contacts to one side of the pump. The other side of the pump is connected to battery negative through the normally-closed contacts of the **K11** contactor. This completes the circuit and causes the pump to run in the "Down" direction.



Circuit Description

The Following Conditions Must Be Met for the Hopper to be Raised and Lowered

- There must be positive voltage to the **J7-1 Interlock Input**. For this to happen:
  - The **Seat Switch S9** must be closed.
  - The **Safety Relay K14** on the **Steer By Wire Controller A5** must energize the coil to close the **Safety Relay K14** contactor.
  - The **Emergency Stop Switch S15** must be closed.
  - The **Battery Interlock S13** must be closed (battery machines) or jumpered (Diesel and LPG machines).
- The **400-amp Fuse F1** must be closed to provide positive voltage from the **Battery** to the load side of **Hydraulic Pump Motor Contactor K12**.
- The **Ignition Switch S14** must be closed to provide positive voltage to the **Auxiliary Contactor K9** coil. The **J2-14 Output** on the **A1 Main Machine Controller** provides ground to the **Auxiliary Contactor K9** coil when the **Ignition Switch S14** provides an input to the **Key Switch Input J7-12**.
- The **Auxiliary Contactor K9** must be closed to provide positive voltage to circuit breaker **VACC1/CB1**.
- The **Hydraulic Pump Motor** circuit breaker **CB8** must closed to provide positive voltage to the load side of the **Hydraulic Pump Motor Contactors K11** and **K12**.
- The load side of the **Hydraulic Pump Motor Contactors K11** and **K12** must be connected to battery ground.
- The **J2-28** and **J2-24 Outputs** must provide negative ground to the **Hydraulic Pump Motor Contactor** coils **K11** and **K12** respectively when the **A1 Main Machine Controller** receives a signal from the **A3 Control Panel** via the **CAN BUS** that the operator has pressed the hopper raise or hopper lower button.

The Following Conditions Must Be Met for the Hopper Door Open and Close

- There must be positive voltage to the **J7-1 Interlock Input**. For this to happen:
  - The **Seat Switch S9** must be closed.
  - The **Safety Relay K14** on the **Steer By Wire Controller A5** must energize the coil to close the **Safety Relay K14** contactor.
  - The **Emergency Stop Switch S15** must be closed.
  - The **Battery Interlock S13** must be closed (battery machines) or jumpered (Diesel and LPG machines).
- The **J3-6** and **J3-7 Outputs** must provide voltage to the **Dump Door Actuator Motor M26** when the **A1 Main Machine Controller** receives a signal from the **A3 Control Panel** via the **CAN BUS** that the operator has pressed the hopper door open or hopper door close button.
  - For the hopper door to open, the **A1 Main Machine Controller** must not receive negative voltage at the **J7-22 Input** from the **Dump Door Extend Limit Switch S7**.
  - For the hopper door to close, the **A1 Main Machine Controller** must not receive negative voltage at the **J7-23** input from the **Dump Door Retract Limit Switch S8**.

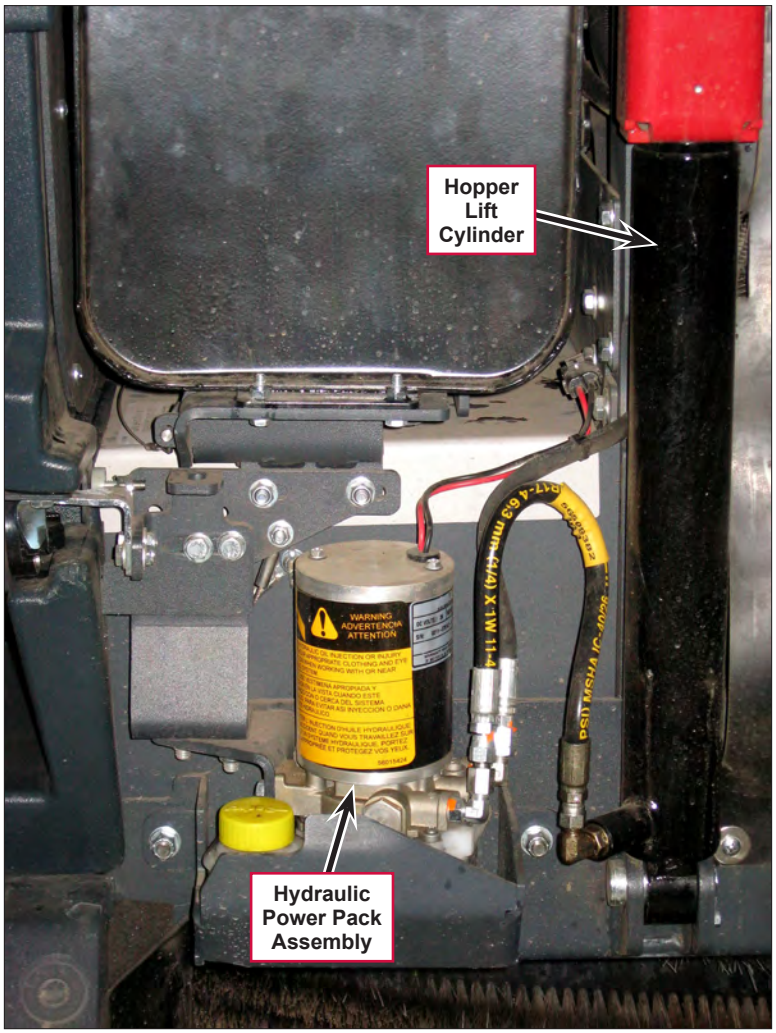
Component Locations

Upper and Lower Hopper

The **Upper Hopper** (light gray) and **Lower Hopper** (dark gray) are on the front of the machine, The **Hopper Cover** houses the dust control impeller pump, filter and filter shaker assembly. The **Upper** and **Lower Hoppers** are connected and pivot up and down as a single unit.

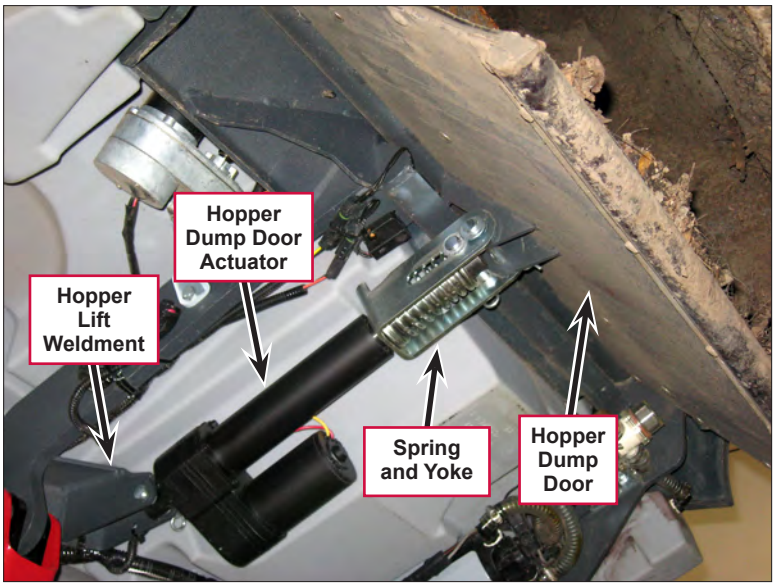
Hydraulic Power Pack Assembly

The **Hydraulic Power Pack Assembly** is mounted on the front of the machine frame and can be accessed when the hopper is up. The **Hydraulic Power Pack Assembly** extends and retracts the **Hopper Lift Cylinder** which raises and lowers the hopper.



Hopper Dump Door

The **Hopper Dump Door** on the bottom of the hopper opens to allow the hopper to be emptied.



Hopper Dump Door Actuator

The electric **Hopper Dump Door Actuator** is pinned to the **Hopper Lift Weldment** and **Hopper Dump Door** and opens and closes the **Hopper Dump Door**.

The **Spring and Yoke** on the rod end of the **Hopper Dump Door Actuator** allow the **Hopper Dump Door** to move a short distance toward the closed position when the **Hopper Dump Door** is open. This is designed to prevent machine damage if the machine is backed away from a dumpster and the **Hopper Dump Door** catches on or contacts the dumpster.

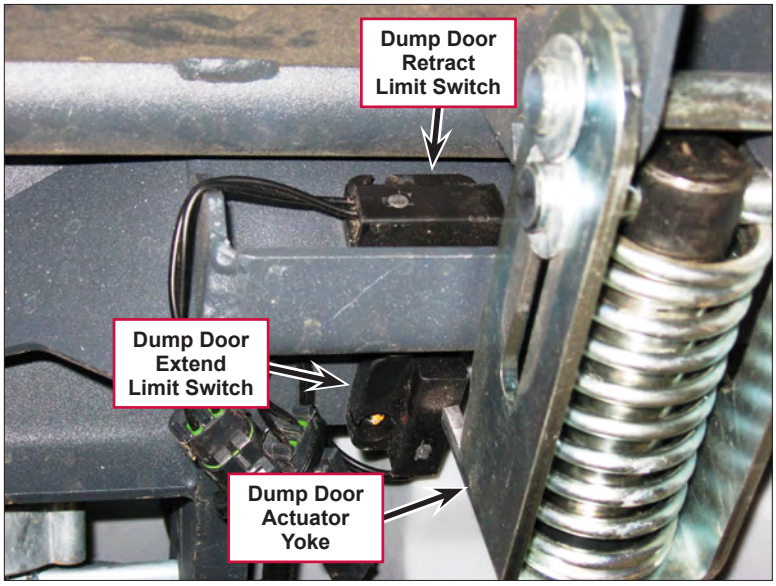
Caution: ***The Spring is pre-compressed about an inch, so use caution if you ever need to disassemble the Spring from the Yoke.***

Dump Door Extend and Retract Limit Switches

The **Dump Door Retract** and **Dump Door Extend Limit Switches** are proximity sensors that sense when the hopper dump door is open (retracted) and closed (extended).

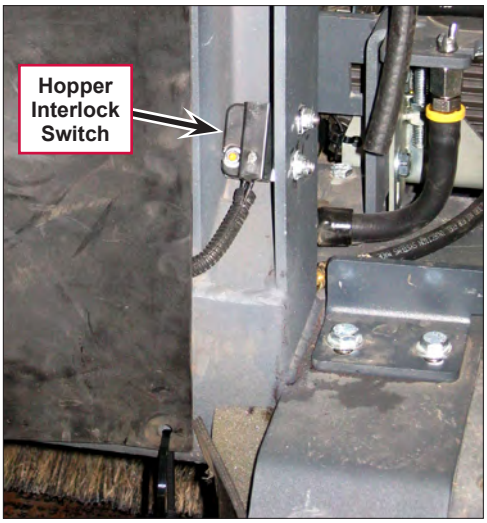
Note that:

- The **Dump Door Extend Limit Switch** senses the **Dump Door Actuator Yoke** when the dump door is closed.
- The **Dump Door Retract Limit Switch** senses the dump door itself when the door is open.



Hopper Interlock Switch

The **Hopper Interlock Switch** is a proximity sensor on the left front of the machine frame that senses when the hopper is all the way down in the normal operating position.



Hopper Prop Rod and Pull Rod

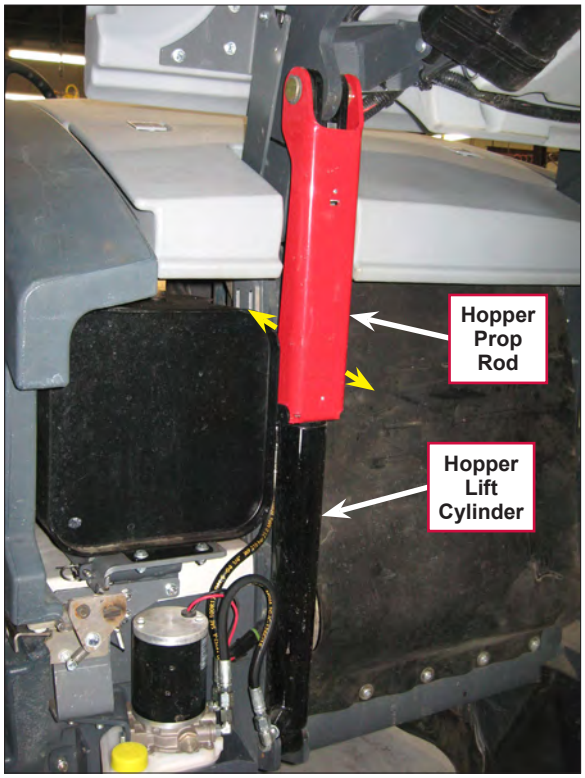
The **Hopper Prop Rod** is a safety mechanism that must be engaged when personnel are working underneath the hopper to prevent the hopper from being lowered. The **Hopper Prop Rod** pivots toward the rear of the machine to engage the top of the **Hopper Lift Cylinder** and hold the hopper in its raised position.

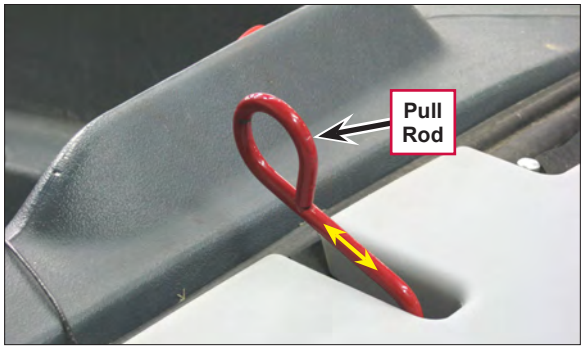
Warning! Before working underneath the raised hopper, engage the Hopper Prop Rod as follows:

1. Raise the hopper all the way up.
2. Pull the **Pull Rod** to pivot the bottom of the **Hopper Prop Rod** toward the **Hopper Lift Cylinder** until it contacts the **Hopper Lift Cylinder**.
3. Lower the hopper until the **Hopper Prop Rod** contacts the top of the **Hopper Lift Cylinder**.

To disengage the **Hopper Prop Rod**:

1. Raise the hopper all the way up.
2. Push the **Pull Rod** to pivot the bottom of the **Hopper Prop Rod** off of the **Hopper Lift Cylinder**.
3. Lower the hopper.





Troubleshooting

Note: *You can use the Service Mode to toggle the various system components on and off to check for function. Refer to the* ***Control System/Service Mode*** *section for information on how to enter and use the Service Mode.*

Problem	Cause	Correction
The hopper will not rise or lower.	An interlock is not closed.	Before you start troubleshooting the hopper system, check to make sure: • The emergency stop switch (**S15**) on the Operator control panel is disengaged (rotate clockwise). • The safety relay from the steering system (**K14**) is closed. • The seat switch (**S9**) is closed. • The battery interlock proximity sensor (**S13**) is closed (battery machines only). • The A1 Main Machine Controller is receiving the appropriate signal from the A3 Control Panel via the CAN BUS.
	There is no voltage to the **K11** and **K12** contactor coils.	Check circuit breaker **CB1 and** reset if necessary.
		The contactor **K9** is not providing positive voltage to the **K11** and **K12** contactor coils. 1. Check the **K9** contactor coil resistance. If the coil resistance is not 118 ohms ± 10%, replace the contactor. 2. Check the continuity through contactor **K9** with the coil energized. If the contacts are open, replace the contactor. 3. Check the **J2-28** and **J2-24 Outputs** from A1 Main Machine Controller.
	There is no voltage to the Hydraulic Pump/Motor Assembly **M10**.	Check circuit breaker **CB8 and** reset if necessary.
		The contactors **K11** and **K12** are not providing voltage to the Hydraulic Pump/Motor Assembly **M10**. 1. Check the coil resistance on the **K11** and **K12** contactor. If the coil resistance is not 117 ohms ± 10%, replace the contactor. 2. Check the continuity through contactors **K11** and **K12** with the coil energized. If the contacts are open, replace the contactor. 3. Check the **J2-28** and **J2-24 Outputs** from A1 Main Machine Controller.
		Check the motor wiring and connections from contactors **K11** and **K12** to the hydraulic pump motor, and the ground connections from the contactors to battery ground. Repair as necessary.

Problem	Cause	Correction
The hopper dump door will not open or close.	Something is physically lodged between the door and the lower hopper.	Check the door and hopper and clear or remove any debris or objects as necessary.
	The **Dump Door Actuator Motor M26** is not operating correctly.	1. Check the wiring and connectors from the A1 Control Board to the dump door actuator motor and repair as necessary. 2. Check the operation of the dump door actuator motor. If the motor doesn't operate with battery voltage applied to it, replace the dump door actuator. 3. Check the voltage outputs from **J3-6** and **J3-7** on the A1 Control Board.
The hopper dump door will not open.	The sensor on the Door Extend Limit Switch (**S7**) is not functioning correctly.	Check the sensor/switch function as follows: • The switch should close when it comes within approximately .250" of a ferrous material. • The switch should open when it moves approximately .313" away from the material. If the switch is not operating correctly, replace the switch.
The hopper dump door will not close.	The sensor on the Door Retract Limit Switch (**S8**) is not functioning correctly.	Check the sensor/switch function as follows: • The switch should close when it comes within approximately .250" of a ferrous material. • The switch should open when it moves approximately .313" away from the material. If the switch is not operating correctly, replace the switch.

Removal and Installation

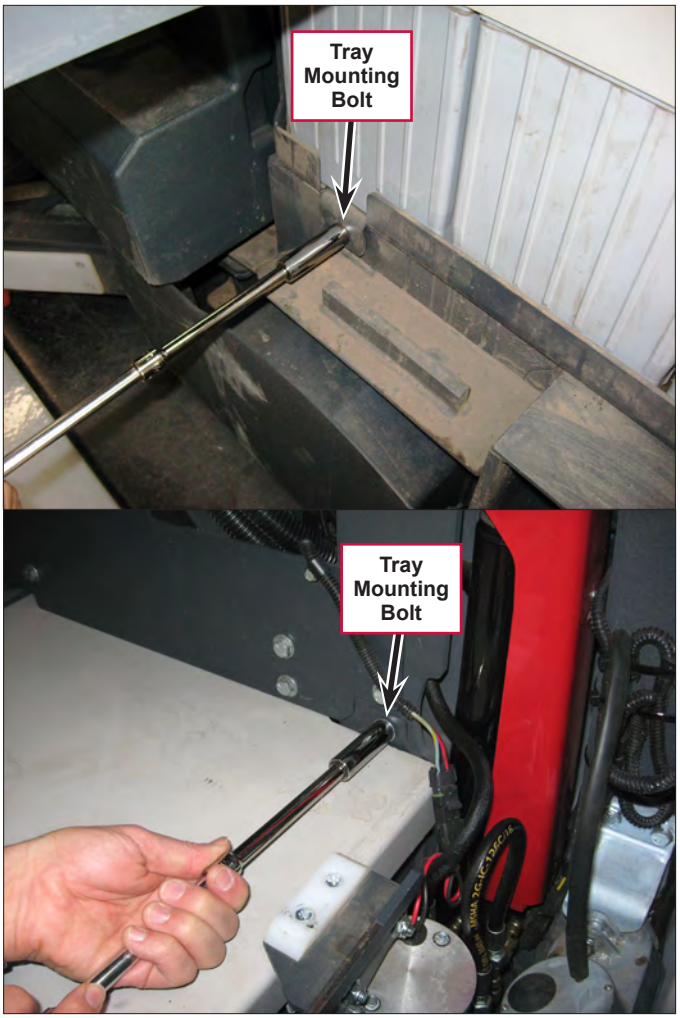
Warning! Before removing or reinstalling any machine components, make sure the key switch is off, the key is removed from the machine and the parking brake is engaged.

To Remove and Reinstall the Hydraulic Power Pack Assembly

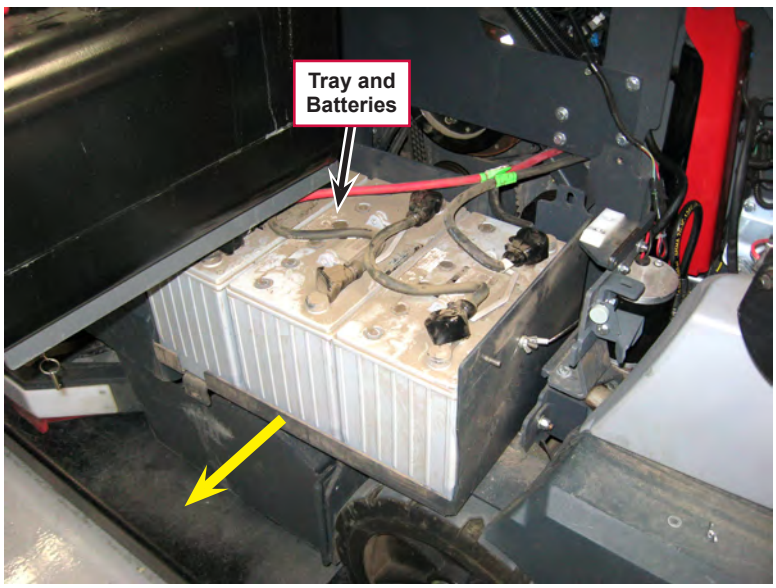
LPG and Diesel Models

1. Disconnect the battery.
2. Open the right engine side cover and remove the right battery tray cover.
3. Swing the fuel tank out.

4. Remove the two **Tray Mounting Bolts** holding the 36-volt battery pack tray to the frame.



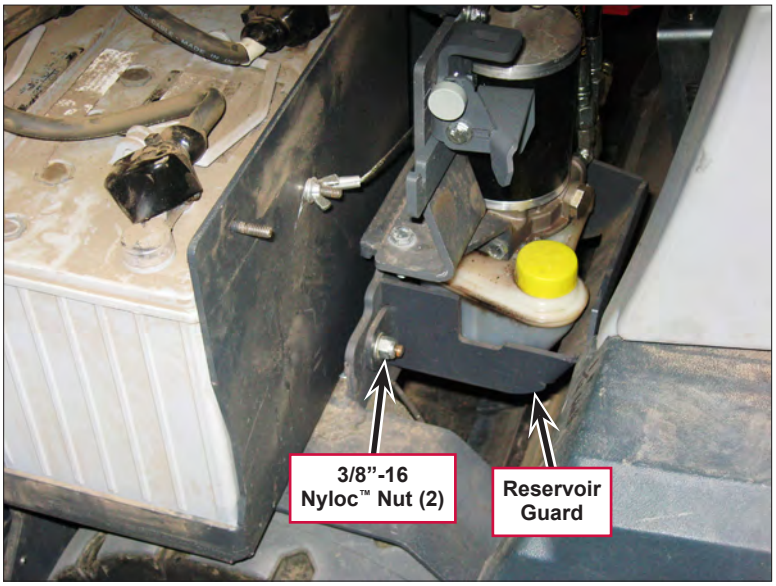
5. Slide the tray with the batteries out to the limit of the tether cable.



6. Use some large hooks to grab the bumper and raise the hopper up slightly using a hoist or other suitable method.

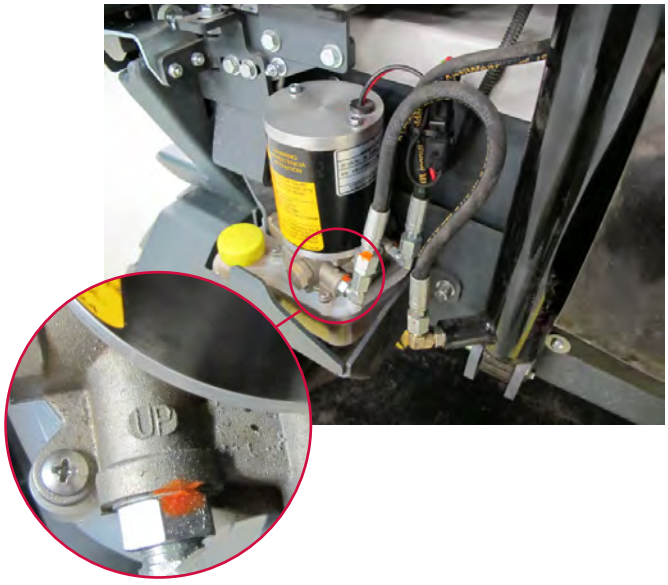
Warning! ***Before working underneath the raised hopper, install blocks between the hopper and chassis, or other suitable supports to prevent the hopper from accidentally lowering while you're working underneath the hopper.***

7. Remove the two **3/8"-16 Nyloc™ Nuts** and remove the **Reservoir Guard**.
8. Disconnect the pump electrical connector.
9. Disconnect the hydraulic hoses from the pump.
10. Remove the two hydraulic pump mounting bolts and remove the Hydraulic Power Pack assembly.
11. Transfer fittings to the new Hydraulic Power Pack assembly and attach the assembly to the frame but do not connect the hoses yet. The system has to be filled with oil.
12. Fill the reservoir with 10W 30 engine oil.



Note: *In the remaining steps it is important that the oil level always be maintained above the minimum mark on the reservoir.*

13. Plug the up port of the pump assembly.(It is labeled on the pump)
14. Momentarily run the pump to get oil out of the "down port" by pressing the hopper down switch.
15. Transfer the plug from the up port to the down port of the pump assembly
16. Momentarily run the pump to get oil out of the "up port" by pressing the hopper up switch.
17. Remove all remaining plugs from the pump and the hoses and attach the hoses to the pump assembly.
    a. Lower cylinder port hose to "up port" on pump
    b. Upper cylinder port hose to "down port" on pump



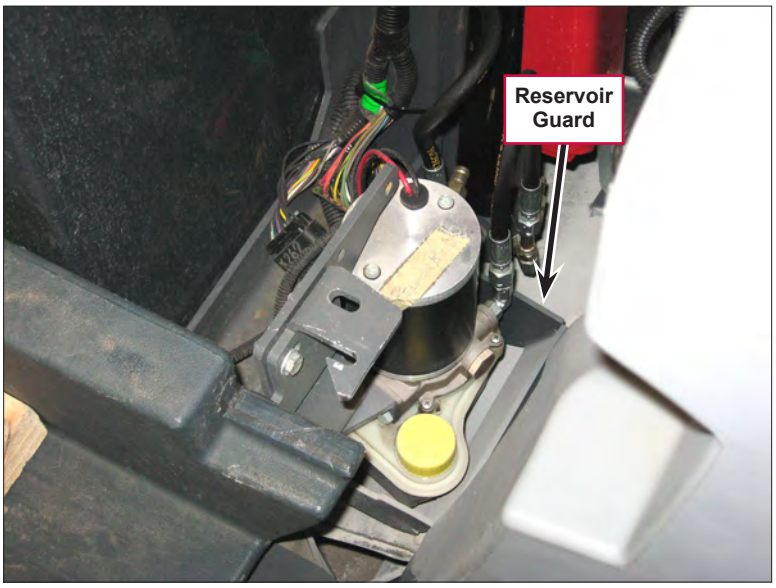
18. Run the hopper to the full up position and make sure the oil level is at the minimum mark on the reservoir.

Battery Models

1. Open the right battery side cover.
2. Use some large hooks to grab the bumper and raise the hopper up slightly using a hoist or other suitable method.

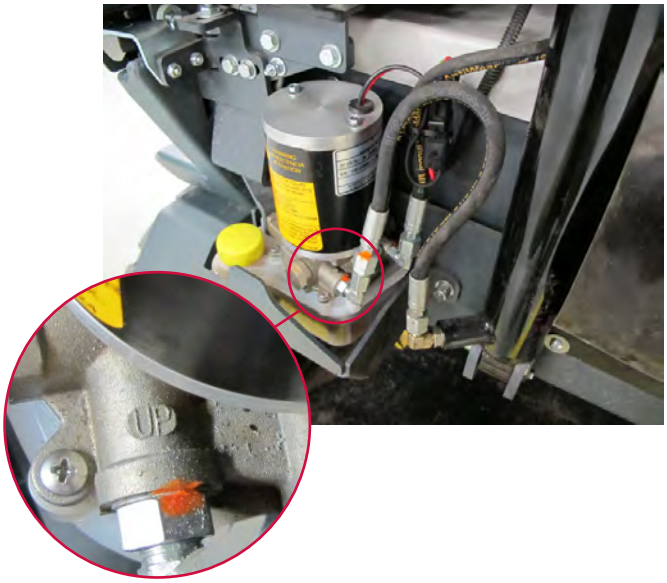
Warning! Before working underneath the raised hopper, install blocks between the hopper and chassis, or other suitable supports to prevent the hopper from accidentally lowering while you're working underneath the hopper.

3. Remove the fasteners and remove the **Reservoir Guard**.
4. Disconnect the pump electrical connector.
5. Remove the hydraulic hoses from the pump.
6. Remove the two hydraulic pump mounting bolts and remove the Hydraulic Power Pack assembly.
7. Transfer fittings to the new Hydraulic Power Pack assembly and attach the assemble to the frame but do not connect the hoses yet. The system has to be filled with oil.
8. Fill the reservoir with 10W 30 engine oil.



Note: *In the remaining steps it is important that the oil level always be maintained above the minimum mark on the reservoir.*

9. Plug the up port of the pump assembly.(It is labeled on the pump)
10. Momentarily run the pump to get oil out of the "down port" by pressing the hopper down switch.
11. Transfer the plug from the up port to the down port of the pump assembly
12. Momentarily run the pump to get oil out of the "up port" by pressing the hopper up switch.
13. Remove all remaining plugs from the pump and the hoses and attach the hoses to the pump assembly.
    a. Lower cylinder hose to "up port" on pump
    b. Upper cylinder hose to "down port" on pump



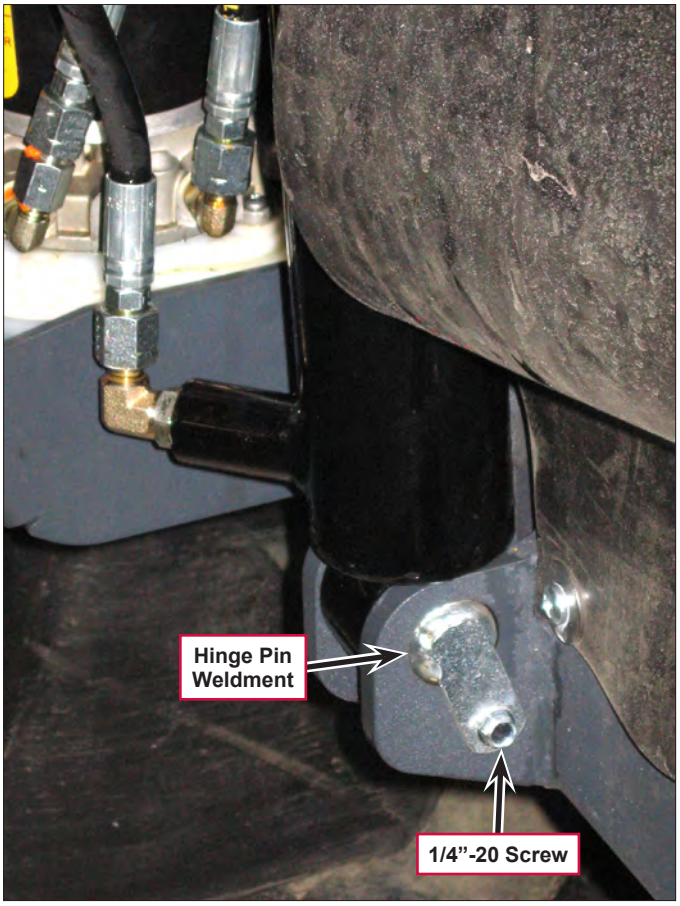
14. Run the hopper to the full up position and make sure the oil level is at the minimum mark on the reservoir.

To Remove and Reinstall the Hopper Lift Cylinder

1. Raise the hopper to a convenient working height.
2. Support the hopper with a hoist to prevent it from falling once the hopper lift cylinder is disconnected.

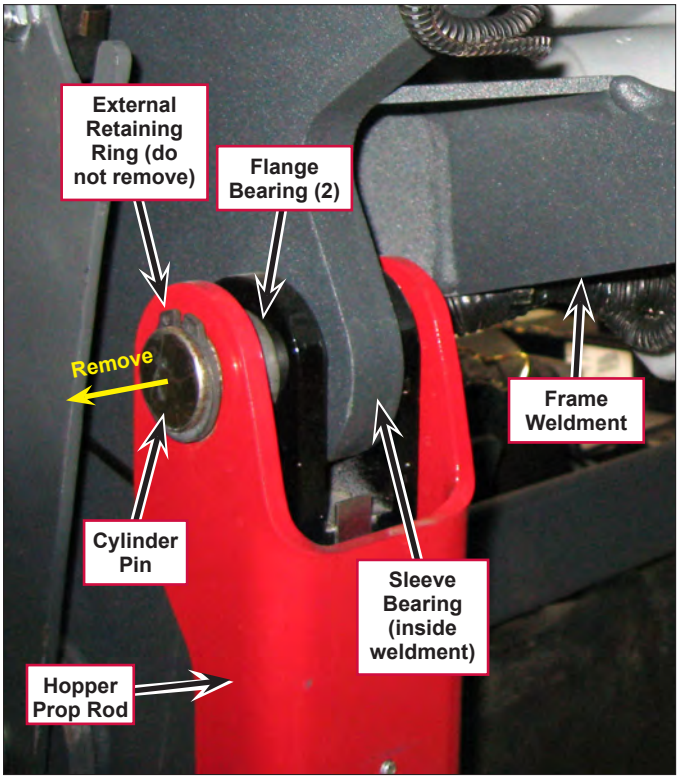
Warning! The hopper must be adequately supported with a hoist before the hopper lift cylinder is disconnected or removed. The hopper prop rod cannot be used to support the hopper when the hopper lift cylinder is disconnected or removed.

3. Place a suitable container under the hopper lift cylinder to catch any hydraulic oil that may leak from the cylinder and hoses.
4. Loosen and disconnect the hoses from the cylinder. Plug the hoses to prevent dirt and air from entering the hoses.
5. Plug the hopper lift cylinder ports to prevent oil from leaking out, and to prevent dirt and air from entering the cylinder.
6. Remove the **1/4”-20 Screw** holding the **Hinge Pin Weldment**, then remove the **Hinge Pin Weldment**.

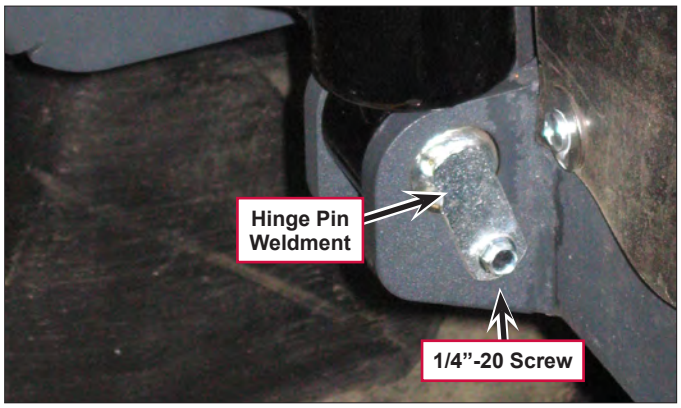


7. There are two **External Retaining Rings** holding the **Cylinder Pin** in position. To remove the **Cylinder Pin**, remove the **External Retaining Ring** next to the **Frame Weldment** as shown.

8. Support the hopper lift cylinder and hopper prop rod. Then remove the **Cylinder Pin**



9. To install the hopper lift cylinder, place it in position at the lower pivot point and reinstall the **Hinge Pin Weldment**, and the **1/4”-20 Screw.**

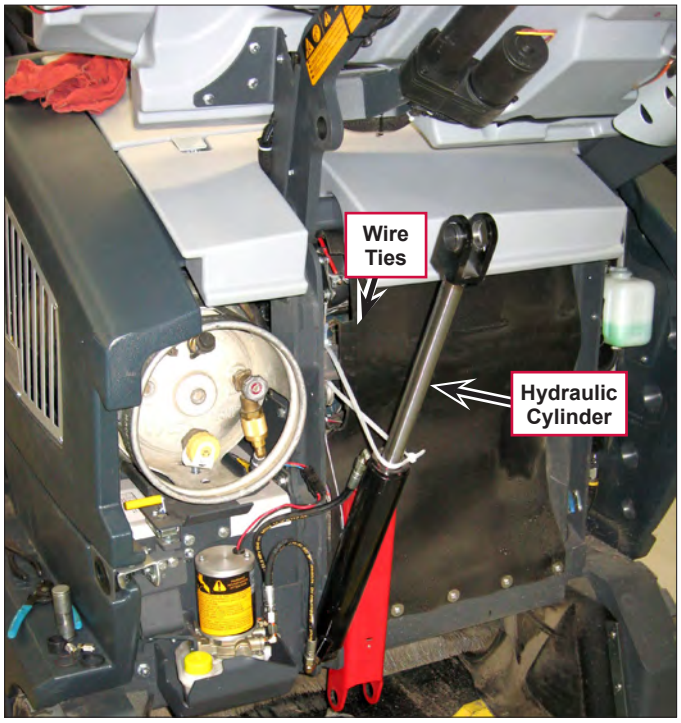


10. Use **Wire Ties** or other suitable strapping to support the **Hydraulic Cylinder** while you work on the system. (See adjacent photo.)

11. Reinstall elbow fittings and attach the hose from the lower cylinder port to the up port on the pump assembly.

12. Fill the reservoir with 10W 30 engine oil.

Note: *In the remaining steps it is important that the oil level always be maintained above the minimum mark on the reservoir.*



13. Operate the pump by pressing the hopper up switch on the control panel until the cylinder is fully extended.

14. Reattach the hose from the upper cylinder to the down port of the pump assembly.

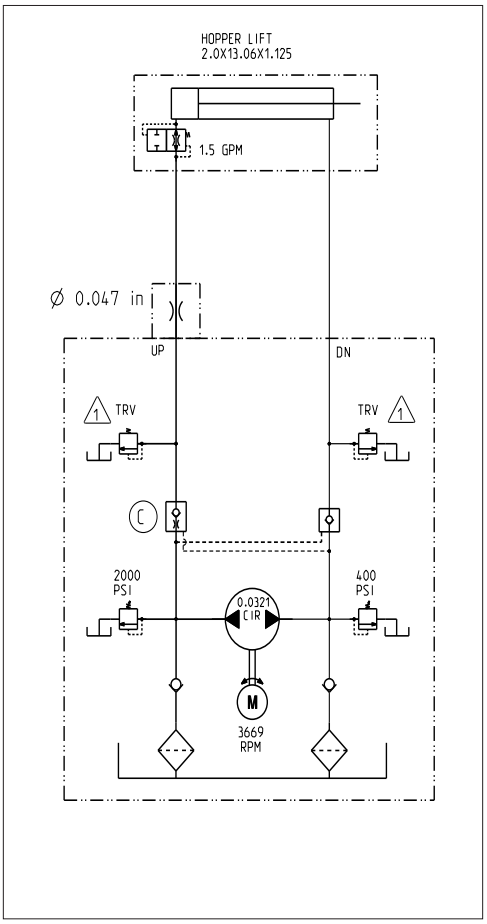
15. Reattach the upper cylinder yoke along with the red safety support, flange bearing, cylinder pin and retaining ring.

16. Run the hopper down and then back to the full up position and make sure the oil level is

at the minimum mark on the reservoir.

To Replace the Oil in the Hydraulic System

Note: *Refer to the adjacent hydraulic system schematic when disassembling and reassembling the hydraulic power pack components.*

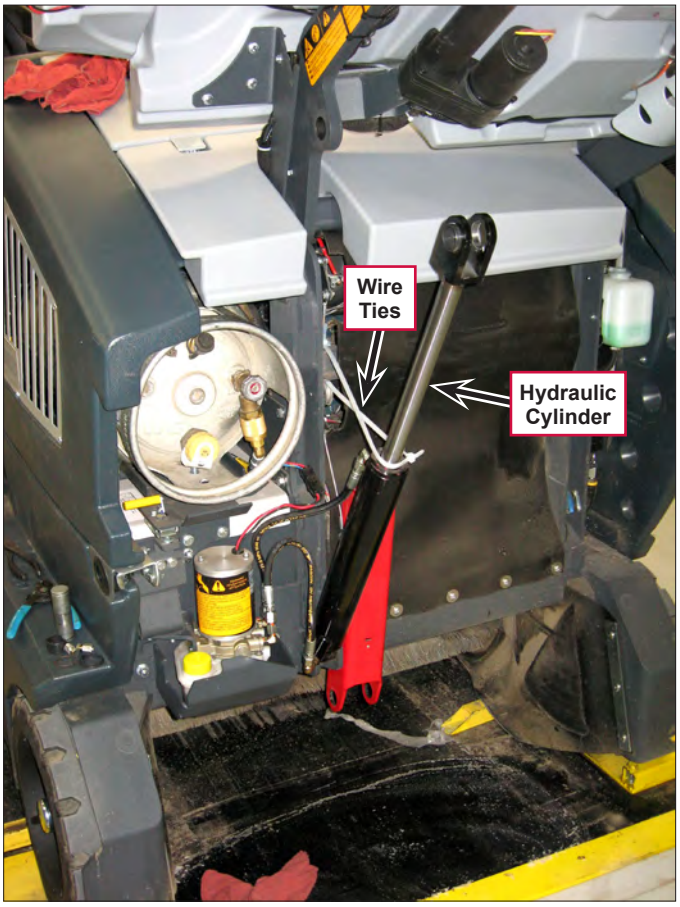


1. Raise the hopper.
2. Engage the parking brake and remove the key from the key switch.
3. Support the hopper in its raised position with an overhead hoist or other suitable support.

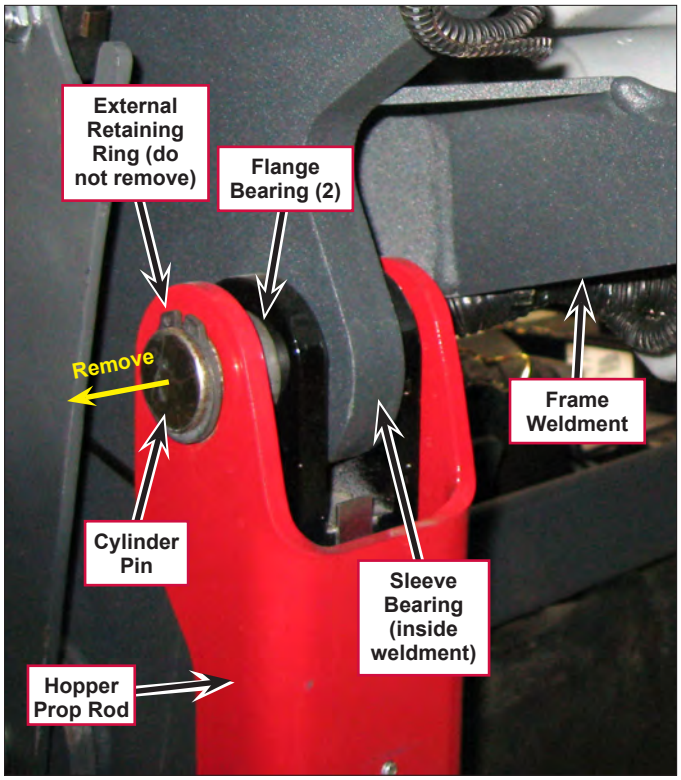
Warning! The hopper must be adequately and securely supported with a hoist or other suitable support before the hopper lift cylinder is disconnected. The hopper prop rod cannot be used to support the hopper when the hopper lift cylinder is disconnected or removed.

4. Remove the **External Retaining Ring** next to the **Frame Weldment** as shown.

5. Use **Wire Ties** or other suitable strapping to support the **Hydraulic Cylinder** while you work on the system.



6. Support the hopper lift cylinder and hopper prop rod. Then remove the **Cylinder Pin**



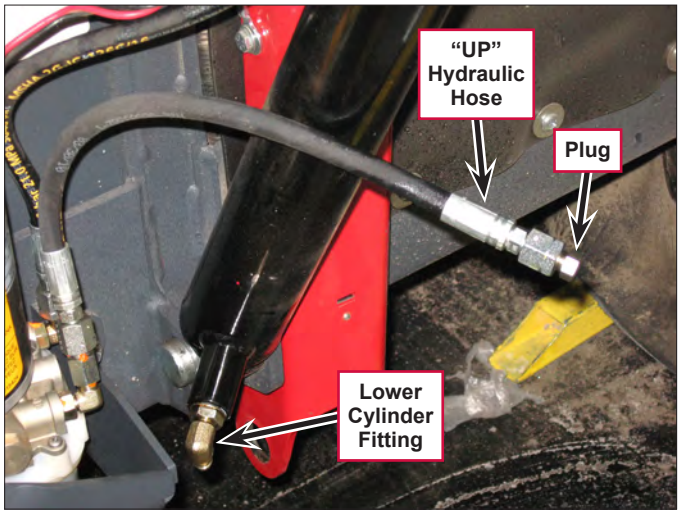
7. Place a drip pan underneath the hydraulic power pack assembly and hydraulic cylinder.

8. Disconnect the **"UP" Hydraulic Hose** from the **Lower Cylinder Fitting**.

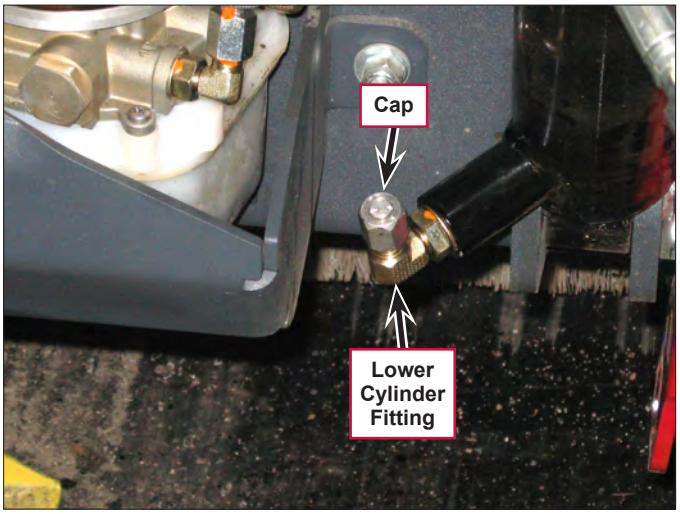
9. Install a **Plug** into the end of the **"UP" Hydraulic Hose**. This will prevent dirt and air from being drawn into the **"UP" Hydraulic Hose** when you run the cylinder rod downward.

10. Rotate the **Lower Cylinder Fitting** downward to direct the oil into the drip pan.

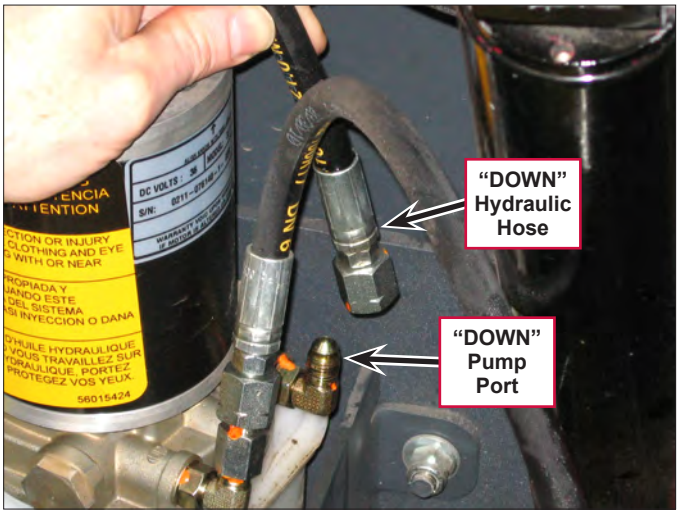
11. Press the hopper lower button to run the pump and force the oil out of the **Lower Cylinder Fitting** until all of the oil has been drained from the bottom of the cylinder. Manually press the cylinder ram down as necessary to ensure all of the oil is out of the bottom of the cylinder.



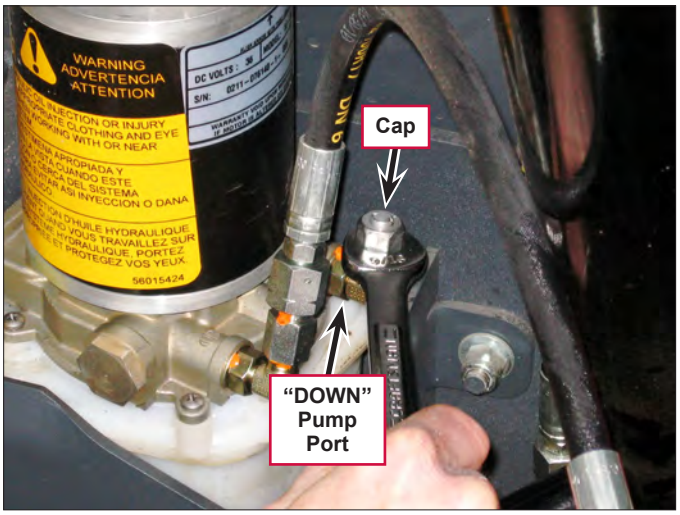
12. Rotate the **Lower Cylinder Fitting** upward back to its original upward position and make sure the **Lower Cylinder Fitting** nut is tight.
13. Install a **Cap** into the **Lower Cylinder Fitting**.



14. Disconnect the **"DOWN" Hydraulic Hose** from the **"DOWN" Pump Port**.

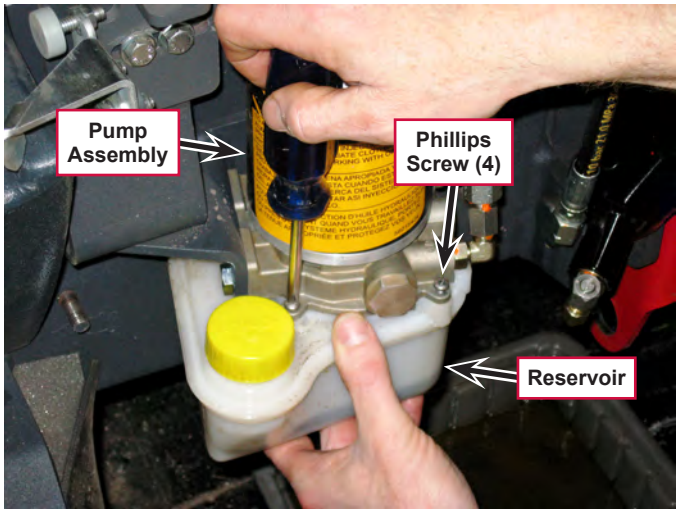


15. Install a **Cap** on the **"DOWN" Pump Port**.



16. Remove the **Reservoir Guard**.

17. Loosen the four **Phillips Screws** holding the **Reservoir** to the **Pump Assembly** and remove the **Reservoir**.



Note: *Leaving the **Phillips Screws** in the **Pump Assembly** will make it easier to reinstall the **Reservoir**.*

18. Empty the oil out of the **Reservoir**. Wipe any dirt or debris out of the **Reservoir** as necessary using a clean, lint-free rag.

19. Check the O-ring between the **Reservoir** and **Pump Assembly** to make sure it is not damaged. Replace the O-ring if necessary.

20. Make sure the O-ring between the reservoir and pump assembly is installed correctly, then reinstall the reservoir onto the pump assembly.

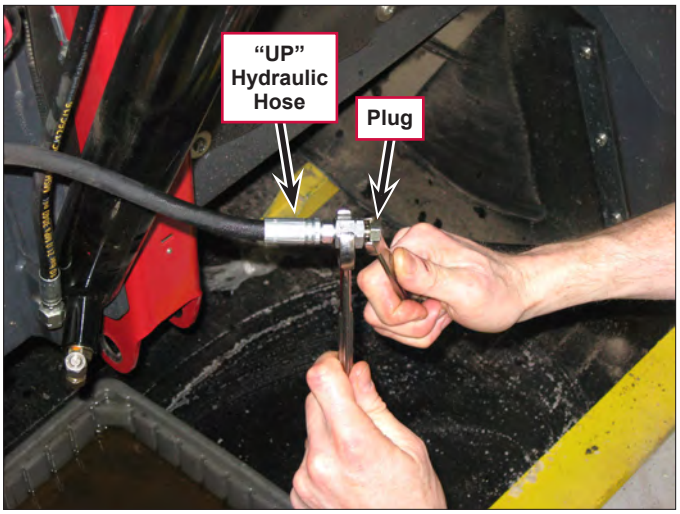
Note: *The reservoir has threaded brass inserts that can be damaged if the Phillips screws are overtightened.*

21. Carefully tighten the four Phillips screws. Do not overtighten.

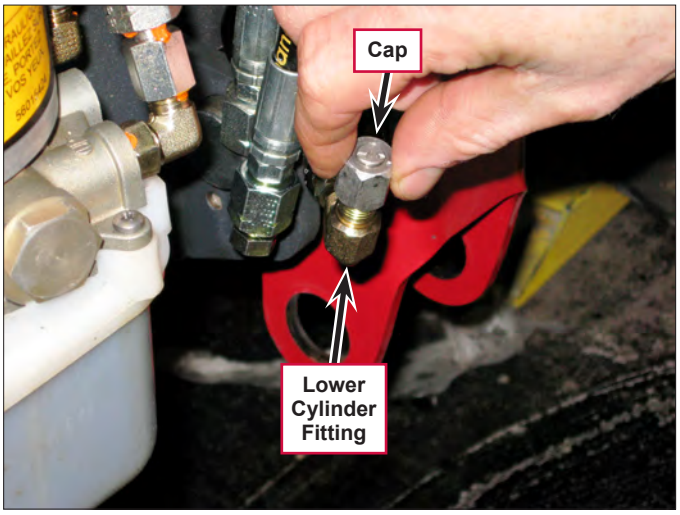
22. Refill the reservoir with 10w-30 oil to the **MAX** fill line. Do not overfill.

23. Loosen the **Plug** on the **"UP" Hydraulic Hose,** then position the end of the **"UP" Hydraulic Hose** over the drip pan.

24. Jog the hopper raise button to run the pump and force the oil out of the **"UP" Hydraulic Hose** until the oil runs clear with no foaming or air evident in the oil.

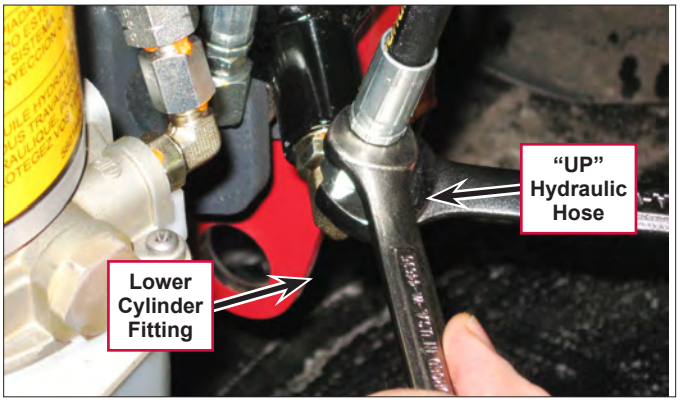


25. Remove the **Cap** from the **Lower Cylinder Fitting**.



26. Remove the **Plug** from the **"UP" Hydraulic Hose** and reconnect the **"UP" Hydraulic Hose** to the **Lower Cylinder Fitting**.

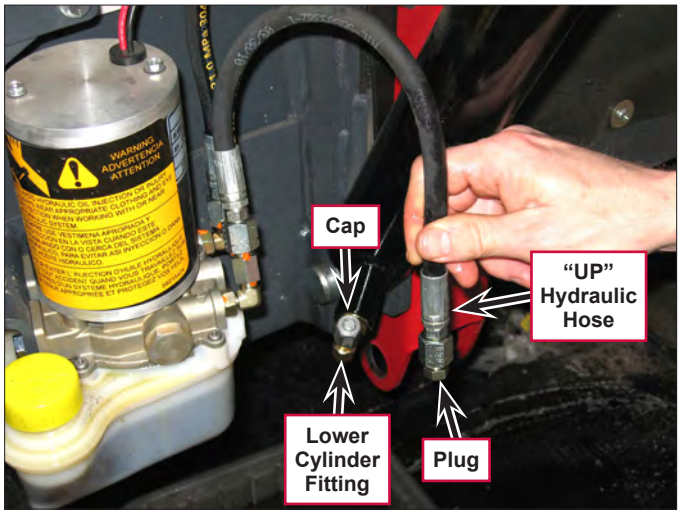
27. Press the hopper raise button to raise the cylinder ram to the end of its stroke to purge the oil from the top of the hydraulic cylinder. Check the oil level in the reservoir frequently as you do this and add oil as necessary. The oil level in the reservoir should be at the **MIN** line with the cylinder ram fully-extended upward.



Note: *Be careful not to let the oil level in the reservoir fall below the **MIN** line to avoid introducing air into the clevis end of the cylinder. If this happens, you will have to restart the procedure from step 8.*

28. Remove the cap from the **"DOWN" Pump Port** and reconnect the **"DOWN" Hydraulic Hose** to the **"DOWN" Pump Port**.

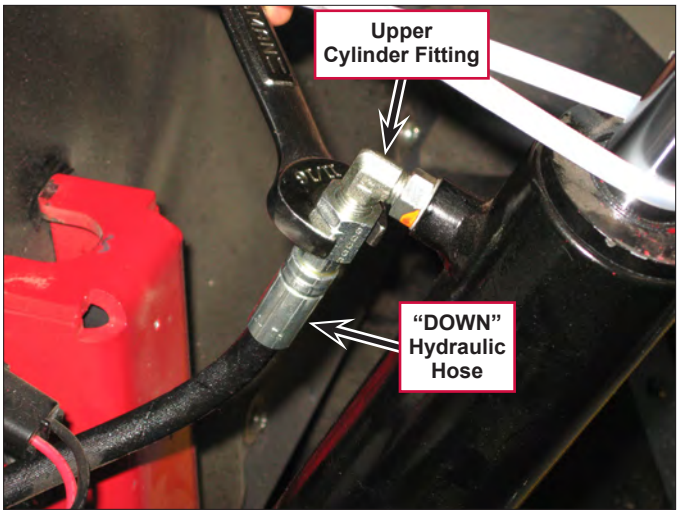
29. Disconnect the **"UP" Hydraulic Hose** from the **Lower Cylinder Fitting**.
30. Install a **Cap** onto the **Lower Cylinder Fitting**.
31. Install a **Plug** into the **"UP" Hydraulic Hose**.



32. Slightly loosen the **"DOWN" Hydraulic Hose** at the **Upper Cylinder Fitting**.

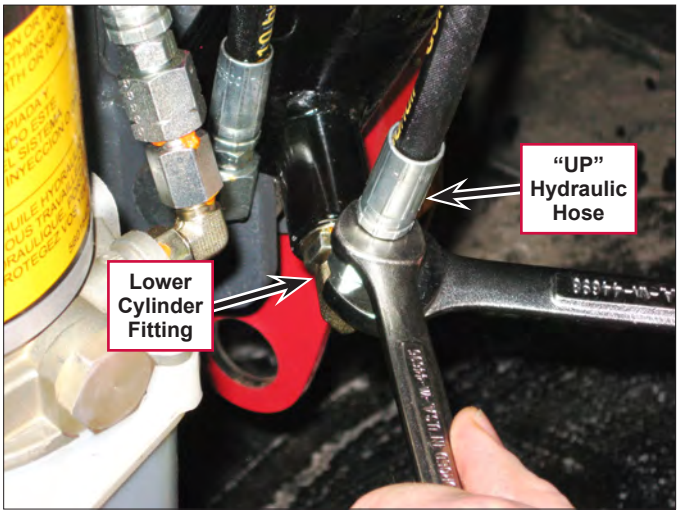
33. Jog the hopper lower button to run the pump and force the oil out of the **"DOWN" Hydraulic Hose** at the **Upper Cylinder Fitting** until the oil runs clear with no foaming or air evident in the oil.

34. Tighten the **"DOWN" Hydraulic Hose** on the **Upper Cylinder Fitting**.



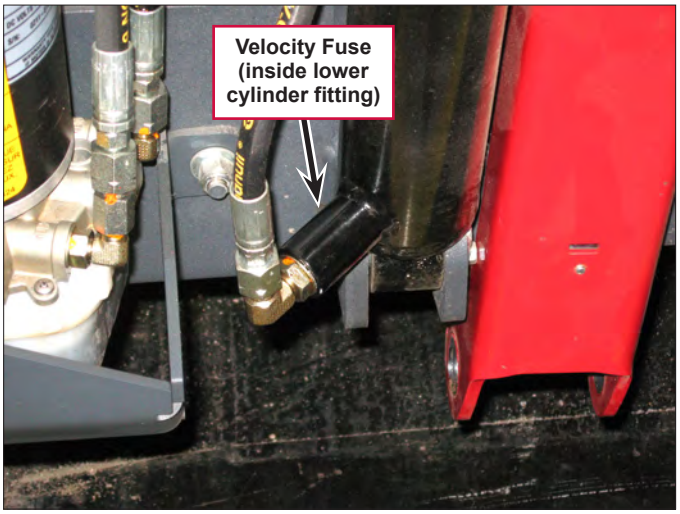
35. Remove the cap from the **Lower Cylinder Fitting**.

36. Remove the plug from the **"UP" Hydraulic Hose** and reconnect the **"UP" Hydraulic Hose** to the **Lower Cylinder Fitting**.



37. Run the hydraulic cylinder ram up and down several times using the hopper raise and hopper lower buttons to check for correct function.

Note: *There is a **Velocity Fuse** inside the lower (down) hydraulic cylinder port that will shut off the flow of oil through the fitting if the oil flow rate exceeds 1.5 gallons per minute. This is to prevent the hopper from dropping down if the "up" hydraulic hose or lower cylinder fitting fails. If the ram fails to retract downward, it could be due to the **Velocity Fuse**. Let the hydraulic system sit idle for a few moments to allow the **Velocity Fuse** to reset, then try retracting the ram again.*

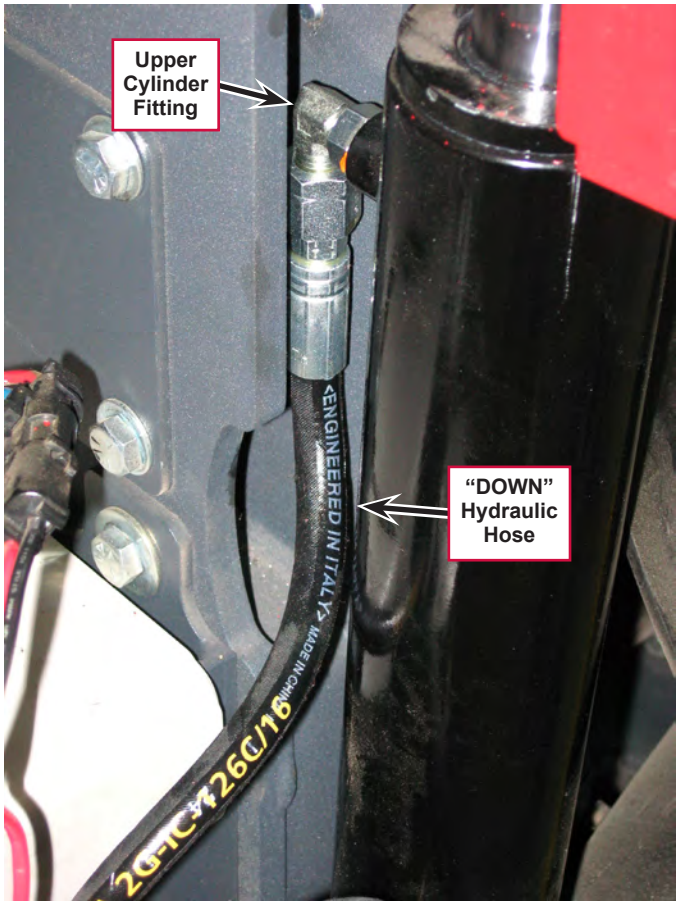


38. Remove the wire ties and reconnect the cylinder ram and prop rod to the hopper lift weldment. Make sure the sleeve bearing and the two flange bearings are not damaged and are installed correctly.

39. Raise the hopper and check the position of the **Upper Cylinder Fitting** and **"DOWN" Hydraulic Hose**.

    - The **Upper Cylinder Fitting** should be positioned vertically and with enough clearance so it doesn't contact the adjacent frame surfaces.
    - The **"DOWN" Hydraulic Hose** should be positioned so it has adequate clearance in the frame cutout.

    Loosen and reposition the **Upper Cylinder Fitting** and **"DOWN" Hydraulic Hose** as necessary to avoid any abrasion or damage.



40. Raise the hopper and check the position of the **"UP" Hydraulic Hose**. The **"UP" Hydraulic Hose** should be positioned as shown so it doesn't contact the hopper when the hopper is down.

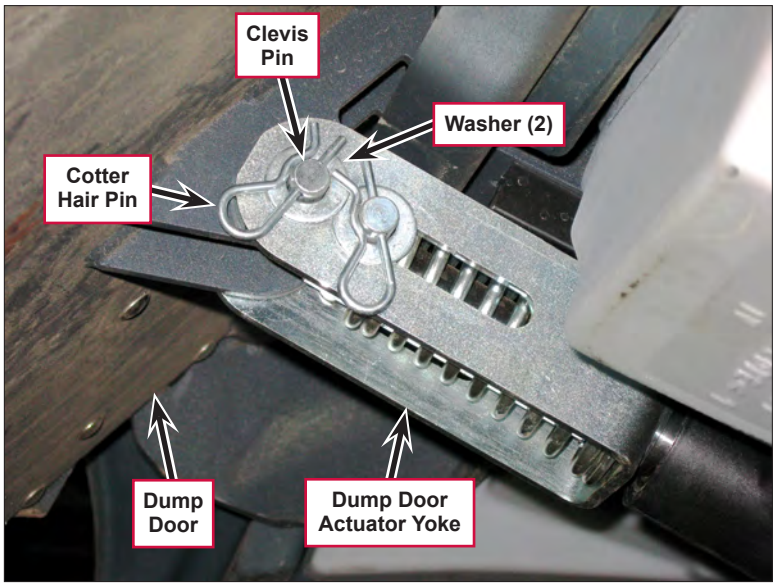
    Loosen and reposition the **"UP" Hydraulic Hose** as necessary to avoid any abrasion or damage.

41. Reinstall the reservoir guard.

42. Check the oil level in the reservoir. It should be at the **MIN** line when the cylinder is fully extended (hopper is raised).

To Remove and Reinstall the Hopper Dump Door Actuator Assembly

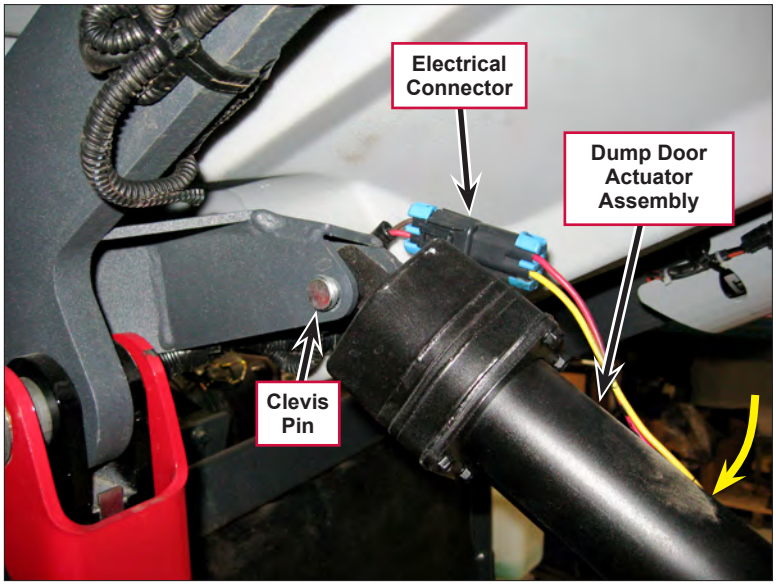
1. Open the hopper and engage the hopper prop rod.
2. Open the hopper dump door to relieve the tension on the hopper dump door actuator assembly.
3. Remove the **Cotter Hair Pin**, **Washers** and **Clevis Pin** holding the **Dump Door Actuator Yoke** to the **Dump Door**.



Note: *Lifting the **Dump Door** up slightly as you remove the **Clevis Pin** will make it easier to remove the **Clevis Pin** from the **Dump Door** and **Dump Door Actuator Yoke**.*

Note: *You don't need to remove the cotter hair pin, washers and clevis pin holding the actuator and spring in the **Dump Door Actuator Yoke**.*

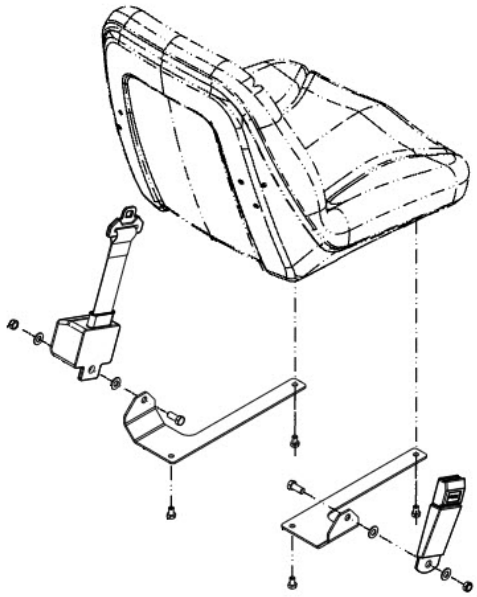
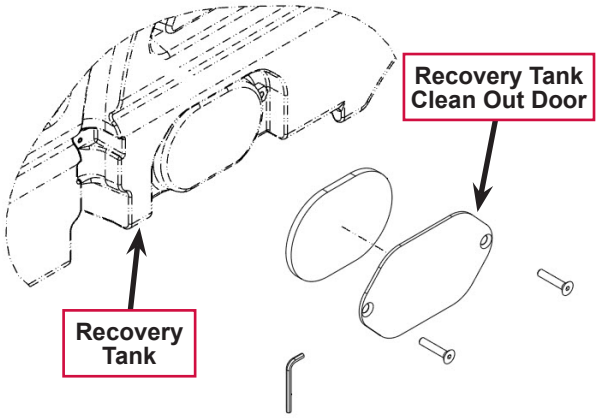
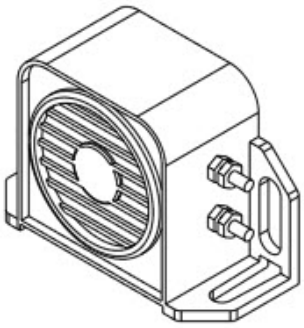
4. Carefully swing the **Door Dump Actuator Assembly** down to access the **Electrical Connector**.
5. Disconnect the **Electrical Connector**.
6. Remove the cotter hair pin, washers and **Clevis Pin** holding the **Dump Door Actuator Assembly** to the frame, then remove the **Dump Door Actuator Assembly** from the machine.
7. Reinstall the hopper dump door actuator assembly by following the above steps in reverse order.

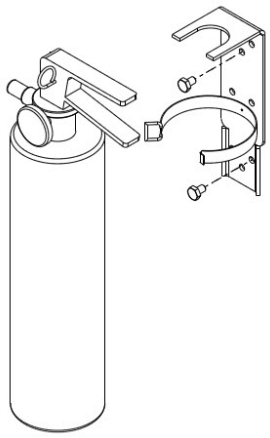


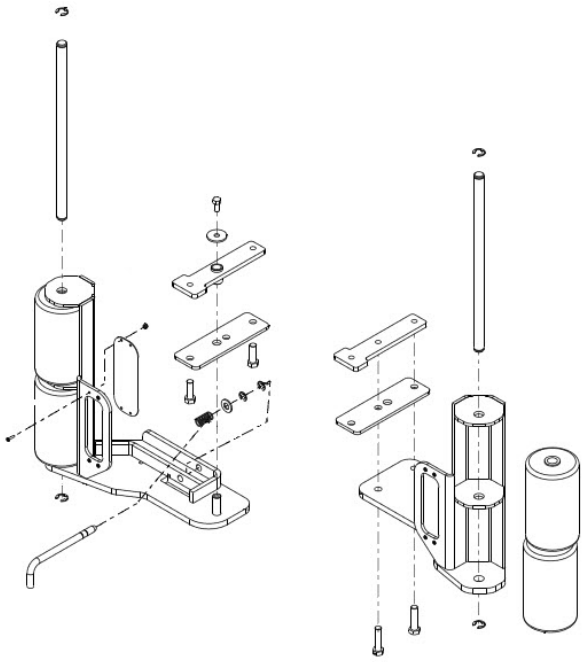
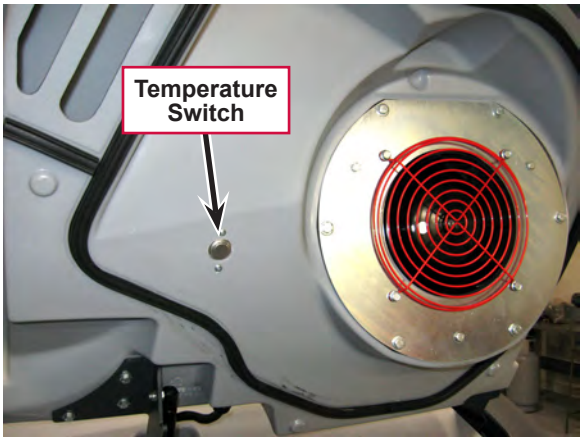
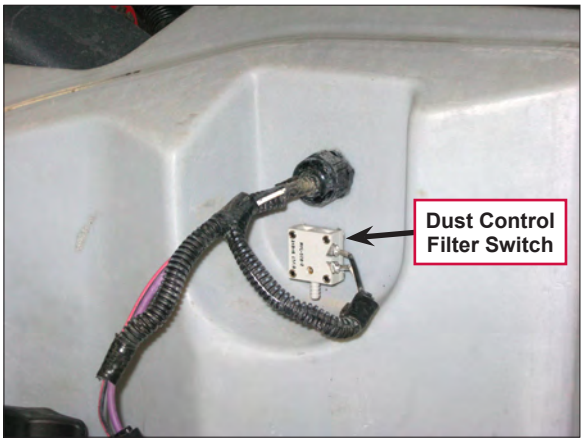
Specifications

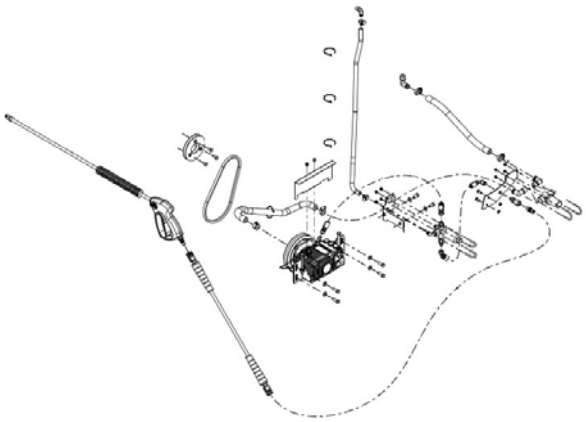
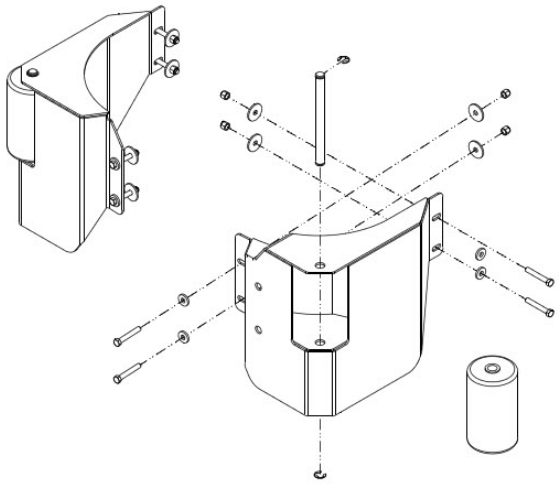
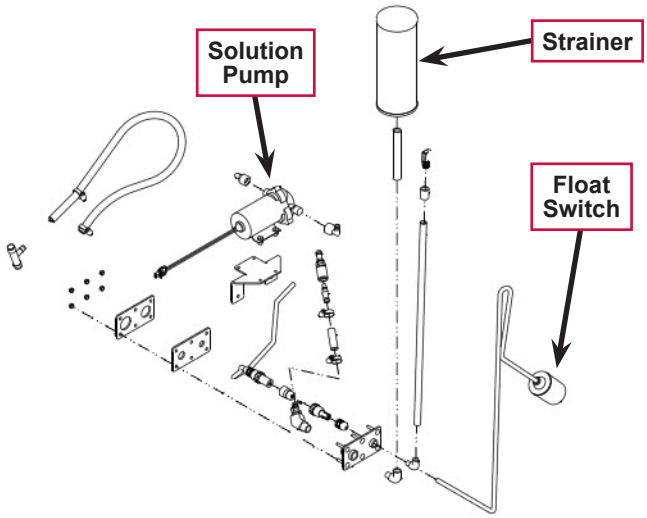
Component	Specifications	
Hydraulic Pump/Reservoir Assembly	Displacement - 0.0321 $in.^3$ per revolution	
	Circuit Type - reversible, locking	
	Reservoir Capacity - 45 $in.^3$ (26 $in.^3$ usable)	
	Oil Type - 10W-30 automotive oil	
Hydraulic Pump Motor	Voltage - 36 VDC	
	Output Torque - 151 ft-lbs.	
	Output Speed - 3669 RPM (full load)	
	Current Draw - 15.9 Amps (full load)	
	Horsepower - 0.55 HP (full load)	
Dump Door Actuator	Voltage - 24 to 40 VDC	
	Stroke - 6 inches	
	Dynamic Load Rating - 400 lbs.	
	Static Load Rating - 1000 lbs.	
	Restraining Torque - 100 in.-lbs.	
	Clutch - ball detent, clutch setting: 600 to 900 lbs.	
	Full Load Speed - 0.55 in./sec	
	Current Rating - 9 Amps	
	Typical Current Draw - 1-3 Amps	
Proximity Sensor (Door Extend and Retract Limit Switches, Hopper Interlock Switch)	Air Gap:	Make - .250” (typical)
		Break - .313” (typical)

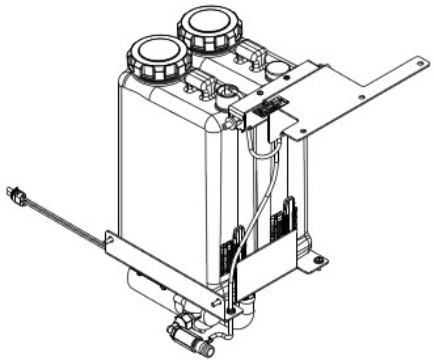
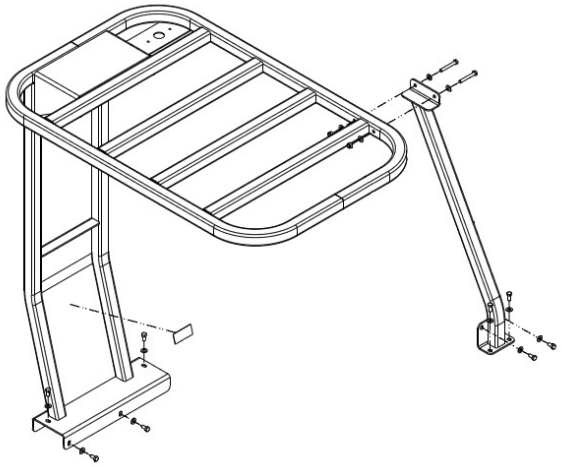
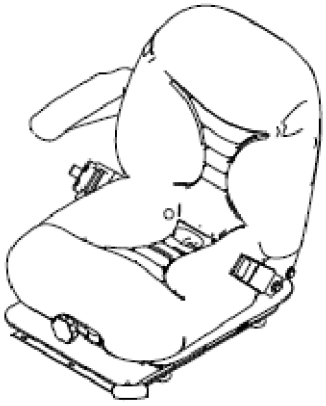
Options and Accessories

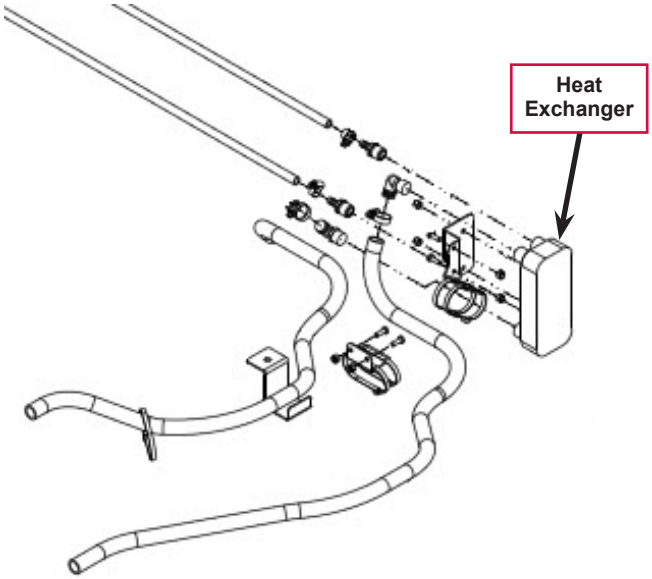
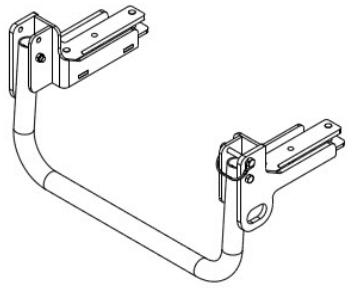
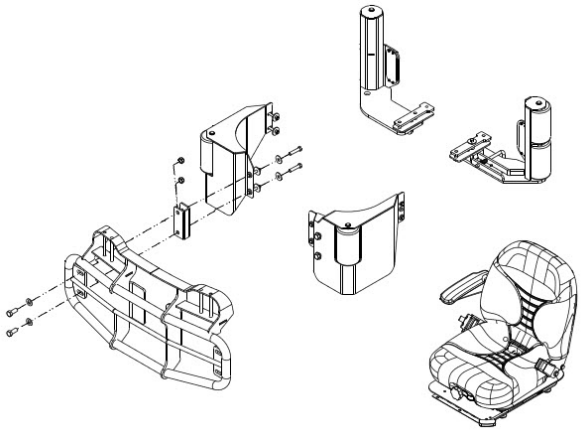
Description	Illustration
Seat Belt Kit	
Recovery Tank Clean Out Kit The Recovery Tank Clean Out Kit includes a removable **Recovery Tank Clean Out Door** to allow easier cleaning and flushing of the **Recovery Tank**.	
Back-Up Alarm Kit The Back-Up Alarm Kit includes the Back-Up Alarm, electrical connector and mounting hardware. The Back-Up Alarm connects to the existing machine wiring to sound a warning when the machine is moving in reverse.	

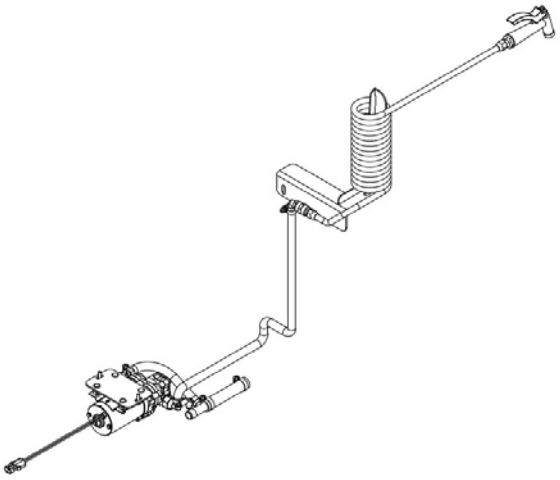
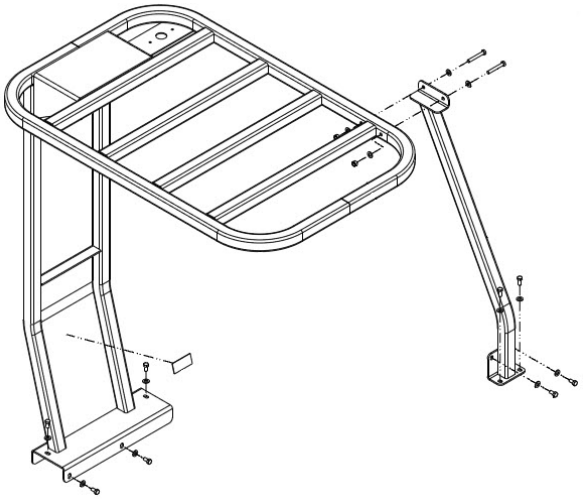
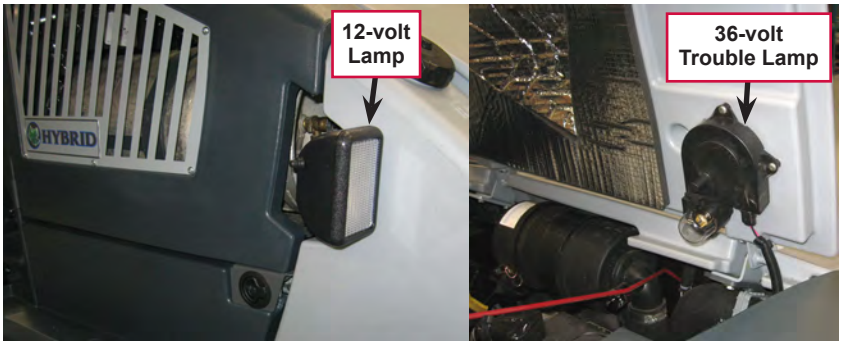
Description	Illustration
Fire Extinguisher Kit	
LED Brake Light/Turn Signal Kit The LED Brake Light/Turn Signal Kit includes front turn signal lights, rear brake/turn signal lights, a rear corner roller kit, mounting hardware and electrical connectors. The main machine controller powers the turn signal lights and brake light. The turn signals don't use a conventional flasher unit. The main machine controller switches the ground to the turn signals on and off.	

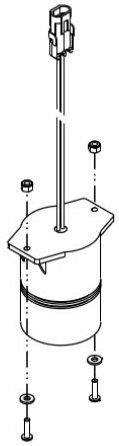
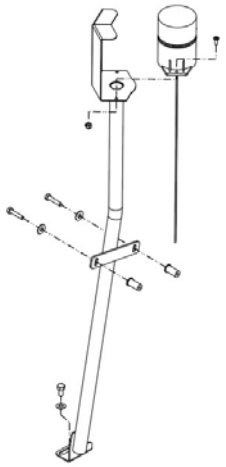
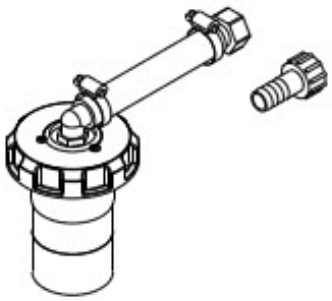
Description	Illustration
Rear Corner Roller Kit	
Hopper Temperature Sensor Kit The Hopper Temperature Sensor Kit includes a **Temperature Switch** and mounting hardware. If the temperature in the hopper rises to a certain point, the **Temperature Switch** will generate a caution and signal the main machine controller to turn off the dust control motor, main broom system and side broom system, and close the hopper dump door.	
Plugged Filter Switch Kit The Plugged Filter Switch Kit includes a **Dust Control Filter Switch** that threads into the hopper and connects to the existing wiring harness. The **Dust Control Filter Switch** will generate a warning if the hopper vacuum gets too high, indicating a plugged dust control filter.	

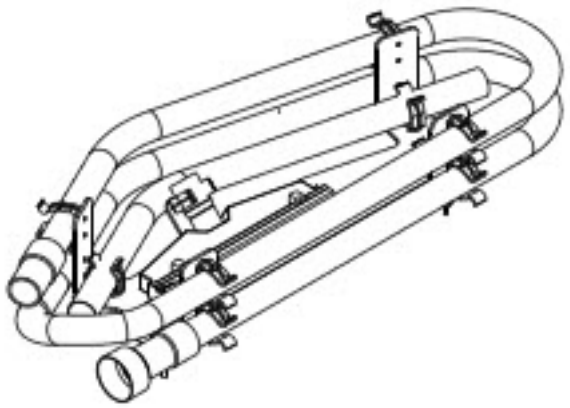
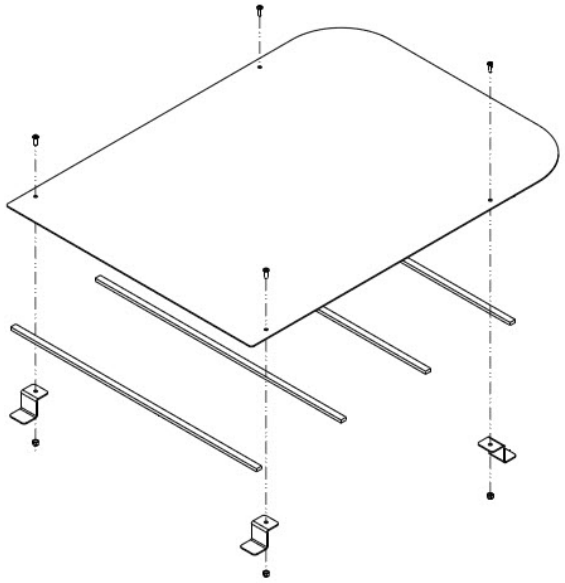
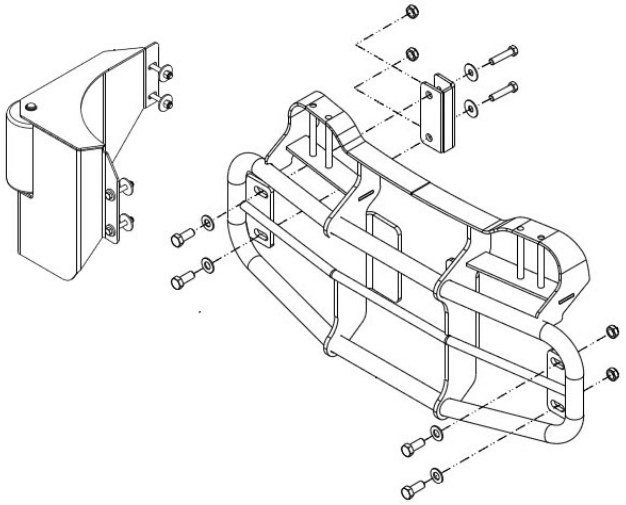
Description	Illustration
High Pressure Pump Kit - LPG and Diesel Hybrids The High Pressure Pump Kit includes a separate high-pressure solution pump, engine-driven pump clutch and drive belt, high-pressure wand assembly, and the associated valves and plumbing. The high-pressure solution pump pumps solution from the tank to the hose and wand when the clutch is engaged. Refer to the ***Solution System*** section for more information.	
Front Corner Roller Kit	
Extended Scrub Kit The Extended Scrub Kit includes an additional **Solution Pump**, a **Float Switch**, **Strainer** and associated plumbing to pump recovered water to the scrub brushes once the solution tank is empty. Refer to the ***Solution System*** section for more information.	

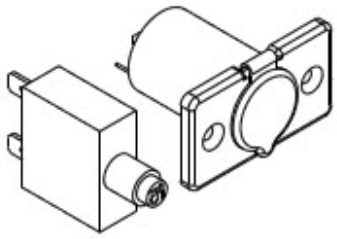
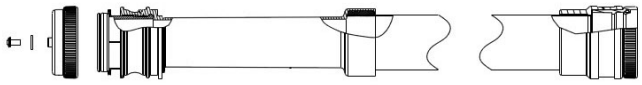
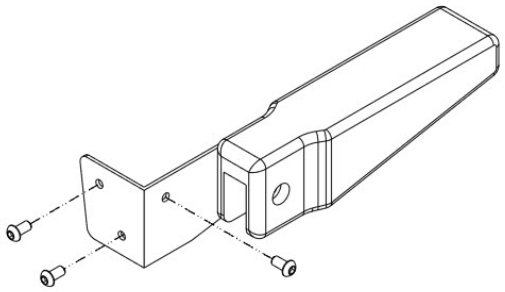
Description	Illustration
EcoFlex™ Chemical Injection Kit The EcoFlex™ Chemical Injection Kit includes the detergent pumps, detergent bottles, mounting hardware and associated plumbing to inject detergent into the solution flow to the scrub brushes. Refer to the ***Solution System*** section for more information.	
Overhead Guard Kit - 79”	
Deluxe Seat Kit	

Description	Illustration
Hot Water Scrub Kit The Hot Water Scrub Kit includes a **Heat Exchanger**, mounting hardware and associated plumbing to route the solution through the **Heat Exchanger** before it is mixed with detergent and sent to the scrub brushes. Routing through the **Heat Exchanger** will increase the solution temperature approximately 50 degrees F. The **Heat Exchanger** is plumbed to the engine cooling system and uses the hot engine coolant to heat the solution as it circulates through the **Heat Exchanger**. Refer to the ***Solution System*** section for more information.	
Squeegee Guard Kit	
Super Duty Kit The Super Duty Kit includes a front bumper kit, deluxe seat kit and a rear corner roller kit.	

Description	Illustration
Spray Wash Hose Kit The Spray Wash Hose Kit includes a separate low-pressure pump to pump solution from the solution tank to the hose and nozzle located behind the Operator seat. An automatic pressure switch will switch on the pump when the hose nozzle is opened, then shut the pump off when the nozzle is closed. Refer to the ***Solution System*** section for more information.	
Overhead Guard Kit - 82”	
Work Light Kit The Work Light Kit includes a 12-volt Lamp, 36-volt Trouble Lamp and mounting hardware. The 12-volt Lamp adds additional lighting to the operator side of the machine for visibility in low-lit areas. The pull-out 36-volt Trouble Lamp is mounted under the hood.	

Description	Illustration
Overhead Guard Beacon Kit The Overhead Guard Beacon Kit includes an LED beacon and electrical connector, and the mounting hardware to mount the beacon onto the overhead guard. The beacon will flash whenever the machine key switch is on.	
Warning Beacon Kit The Warning Beacon Kit includes an LED warning beacon and electrical connector, and the mounting hardware to mount the beacon onto the machine. The beacon will flash whenever the machine key switch is on.	
Solution Fill Shut-Off Kit The Solution Fill Shut-Off Kit allows you to connect a garden hose to the fitting and fill the solution tank without having to monitor the water level in the tank. When the solution tank is full, a float valve will automatically shut off the water flow into the tank.	

Description	Illustration
Vacuum Wand Kit	
Overhead Guard Canopy Kit	
Front Bumper Kit The Front Bumper Kit includes the front bumper weldment, a front corner roller kit and mounting hardware.	

Description	Illustration
Accessory Socket Kit The Accessory Socket Kit includes a 12-volt “automotive” type adapter to power accessories or personal electronics, and a circuit breaker.	
Drain Hose Extension	
Arm Rest Option (R/H Only)	

Recovery System

Functional Description

Overview

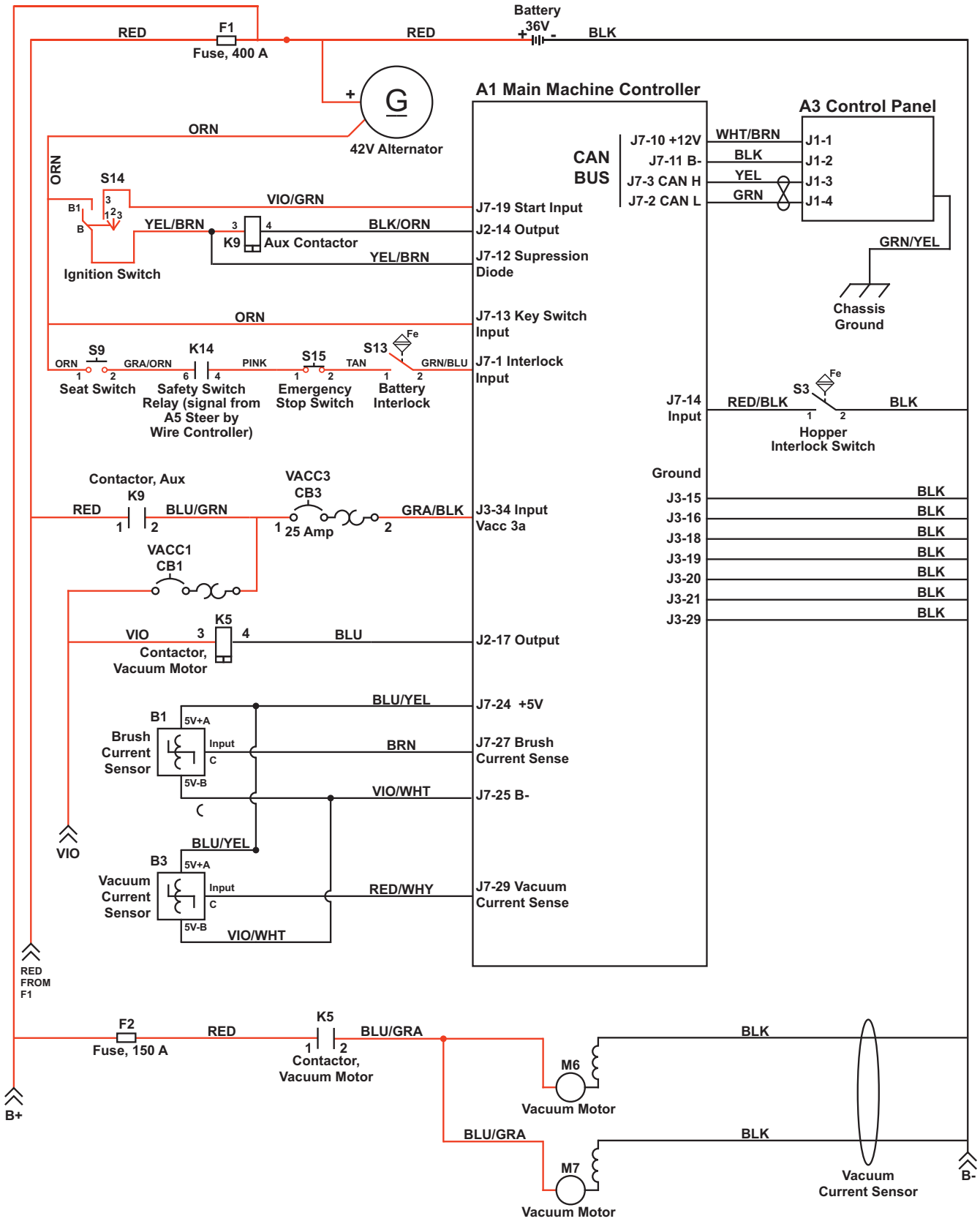
The recovery system picks up the scrubbing solution from the floor and directs it to the recovery tank. Two vacuum motors draw air from the recovery tank to create a vacuum in the tank and at the squeegee to pick up the solution. The solution travels through the squeegee hose, through a debris basket which catches any large particles, then into the recovery tank.

The vacuum motors switch on automatically when the scrub system is enabled and the machine moves forward. The motors will switch off after a predetermined time delay once machine motion stops.

The vacuum motors can also be switched on independent of the scrub system by pressing the vacuum/wand switch. This is used to pick up solution already on the floor, or when using a wand on the squeegee hose.

A current sensor monitors the combined current draw of both vacuum motors and will display a fault if the vacuum motor current draw is too high.

Recovery System Wiring Diagram



Circuit Description

The following conditions must be met for the recovery system to operate:

- The **Hopper Interlock Switch S3** must be closed.
- There must be positive voltage to the **J7-1 Interlock Input**. For this to happen:
  - The **Seat Switch S9** must be closed.
  - The **Safety Relay K14** on the **Steer By Wire Controller A5** must energize the coil to close the **Safety Relay K14** contactor.
  - The **Emergency Stop Switch S15** must be closed.
  - The **Battery Interlock S13** must be closed.
- The **400-amp Fuse F1** must be closed to provide positive voltage from the **Battery** to the load side of **Auxiliary Contactor K9**.
- The **Ignition Switch S14** must be closed to provide positive voltage to the **Auxiliary Contactor K9** coil. The **J2-14 Output** on the **A1 Main Machine Controller** provides ground to the **Auxiliary Contactor K9** coil when the **Ignition Switch S14** provides an input to the **Key Switch Input J7-13**.
- The **Auxiliary Contactor K9** must be closed to provide positive voltage to circuit breaker **VACC1/CB1**.
- Circuit breaker **VACC1/CB1** must be closed to provide positive voltage to the **Vacuum Motor Contactor K6**.
- The **J2-17 Output** on the **A1 Main Machine Controller** must provide a ground to the **Vacuum Motor Contactor K6** coil. **J2-17** provides ground to **K6** under the following conditions:
  - The **A1 Main Machine Controller** must receive a signal from the **A3 Control Panel** via the **CAN BUS** that the operator has pressed the scrub switch.
  - The **A1 Main Machine Controller** must receive a signal from the **A2 Drive Controller** via the **CAN BUS** that the machine is moving forward.
  - The voltage to **J7-29 Vacuum Current Sense** on the **A1 Main Machine Controller** from the **Vacuum Current Sensor B3** must be within the acceptable range to indicate both vacuum motors are working correctly.
- The **150-amp Fuse F2** must be closed to provide positive voltage from the **Battery** to the load side of the **Vacuum Motor Contactor K6**.
- The **Vacuum Motor Contactor K6** contacts must be closed.
- The **Vacuum Motors M6** and **M7** must have connections to battery ground **B-**.

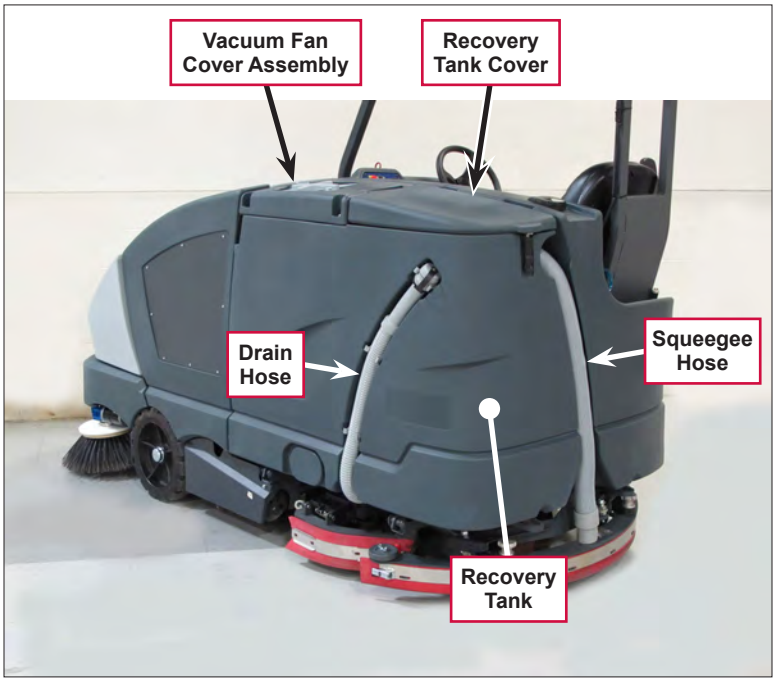
Component Locations

Recovery Tank

The **Recovery Tank** is on the left rear side of the machine. The **Squeegee Hose** carries the scrub solution from the squeegee to the **Recovery Tank**. The **Drain Hose** allows you to empty the **Recovery Tank**.

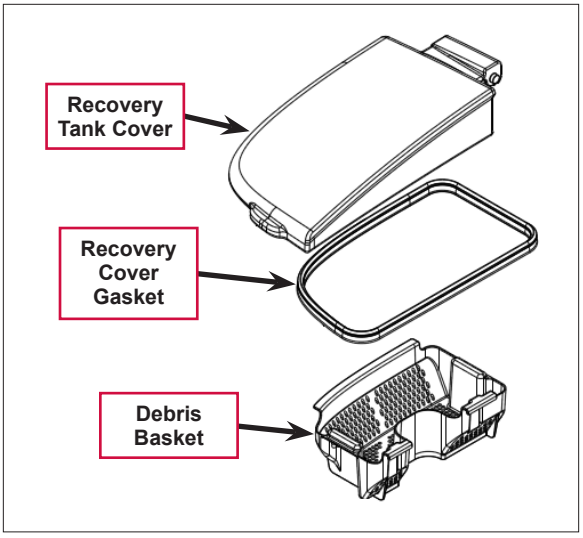
The vacuum motors are located underneath the **Vacuum Fan Cover Assembly**.

The debris basket can be accessed by opening the **Recovery Tank Cover**.



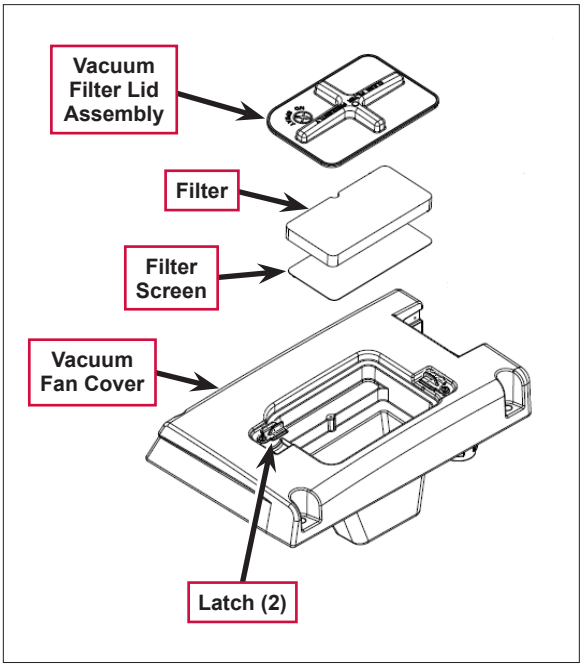
Recovery Tank Cover and Debris Basket

The **Debris Basket** is located below the **Recovery Tank Cover** and attached **Recovery Cover Gasket**. The recovered solution is directed through the **Debris Basket** before going into the recovery tank to screen out any debris or large particulates.



Vacuum Fan Cover Assembly

The **Vacuum Fan Cover Assembly** includes the **Vacuum Filter Lid Assembly**, **Filter**, **Filter Screen** and **Vacuum Fan Cover**. The **Vacuum Fan Cover Assembly** fastens to the top of the **Recovery Tank**. The two plastic **Latches** rotate to allow the **Vacuum Filter Lid Assembly** to be removed to access the **Filter** and **Filter Screen**.

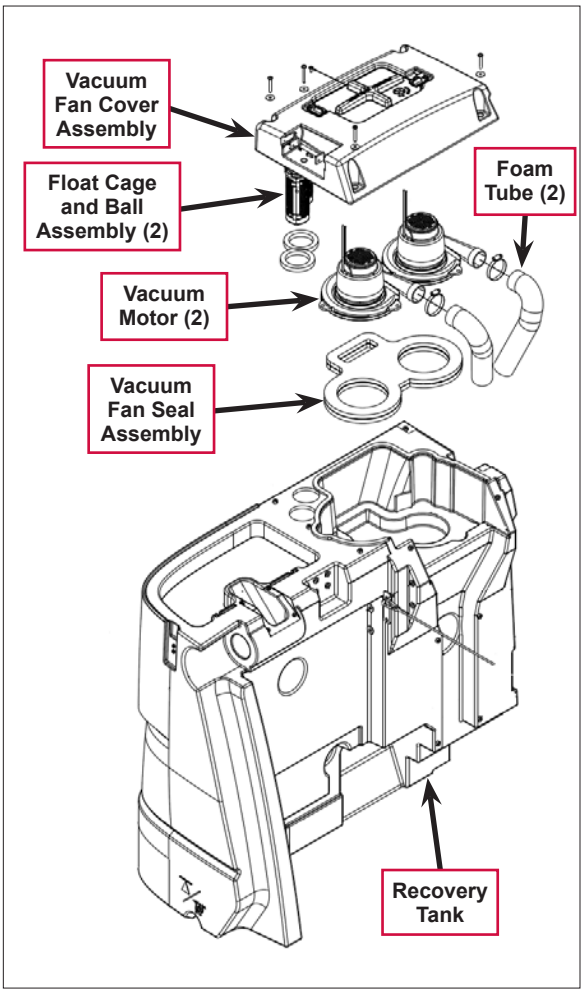


Vacuum Motors

The **Vacuum Motors** sit on the **Vacuum Fan Seal Assembly** in the **Recovery Tank** and are held in place by the **Vacuum Fan Cover Assembly**. The air from the **Vacuum Motors** is exhausted through **Foam Tubes** no minimize noise.

Float Cage and Ball Assemblies

The **Float Cage and Ball Assemblies** are attached to the **Vacuum Fan Cover Assembly** and prevent any recovered water from being drawn in through the **Vacuum Motors**.

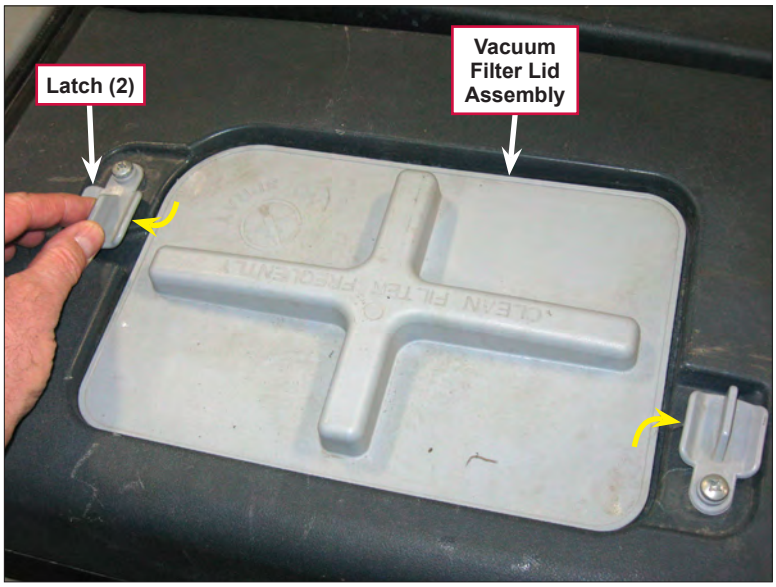


Maintenance and Adjustments

Warning! ***Before performing any machine maintenance or adjustments, make sure the key switch is off, the key is removed from the machine and the parking brake is engaged.***

To Clean the Vacuum Filter and Filter Screen

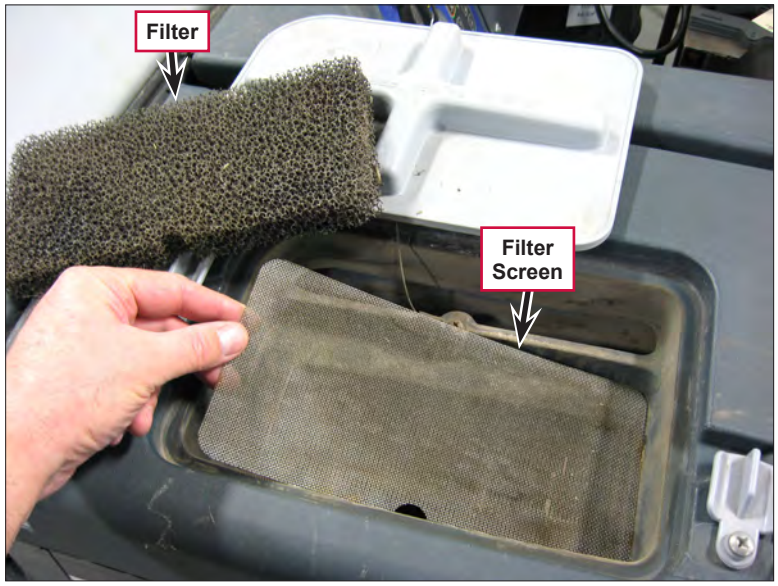
1. Rotate the two **Latches** 90 degrees and remove the **Vacuum Filter Lid Assembly**.



2. Remove and clean the **Filter** and **Filter Screen** with a vacuum, or by washing them in warm water.
3. When the **Filter** and **Filter Screen** are clean and dry, reinstall them into the recovery tank.

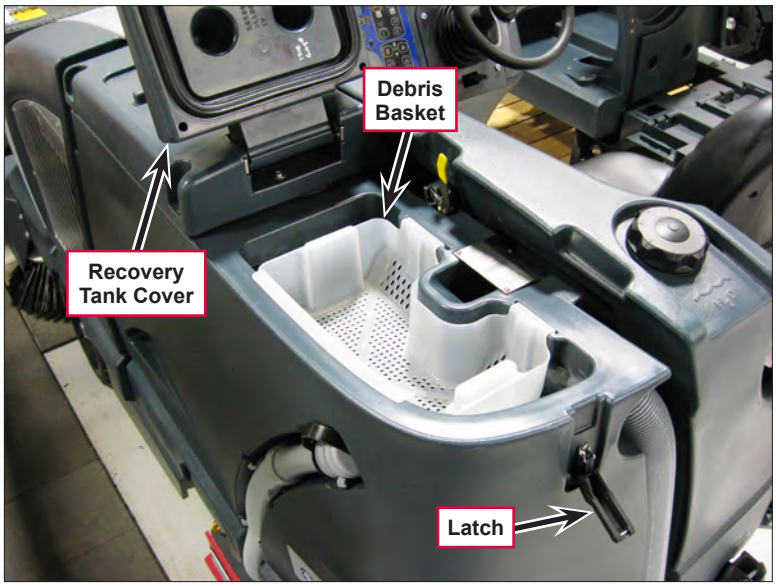
Service Note: *The* ***Filter*** *and* ***Filter Screen*** *must be completely dry before reinstalling.*

4. Rotate the two **Latches** back 90 degrees to secure the **Vacuum Filter Lid Assembly**.



To Clean the Debris Basket

1. Unhook the **Latch**, open the **Recovery Tank Cover** and lift the **Debris Basket** out of the recovery tank.
2. Rinse any accumulated material from the **Debris Basket**, then reinstall it in the recovery tank.
3. Close the **Recovery Tank Cover** and secure the **Latch**.



Troubleshooting

Note: *You can use the Service Mode to toggle the various system components on and off to check for function. Refer to the* ***Control System/Service Mode*** *section for information on how to enter and use the Service Mode.*

Problem	Cause	Correction
Neither of the vacuum motors will run.	An interlock is not closed.	Before you start troubleshooting the recovery system, check to make sure: • The emergency stop switch (**S15**) on the Operator control panel is disengaged (rotate clockwise). • The safety relay from the steering system (**K14**) is closed. • The seat switch (**S9**) is closed. • The battery interlock proximity sensor (**S13**) is closed. • The A1 Main Machine Controller is receiving the appropriate signal from the A3 Control Panel via the CAN BUS.
	The 150-amp Fuse (**F2**) is blown.	Check the Fuse (**F2**) and replace if necessary.
	There is no voltage to the **K5** contactor coil.	Check circuit breaker **CB1** reset if necessary.
		The contactor **K9** is not providing positive voltage to the **K5** contactor coil. 1. Check the **K9** contactor coil resistance. If the coil resistance is not 118 ohms ± 10%, replace the contactor. 2. Check the continuity through contactor **K9** with the coil energized. If the contacts are open, replace the contactor. 3. Check the **J2-14** output from A1 Main Machine Controller.
	There is no voltage to the vacuum motors.	1. Check the **K5** contactor coil resistance. If the coil resistance is not 118 ohms ± 10%, replace the contactor. 2. Check the continuity through contactor **K5** with the coil energized. If the contacts are open, replace the contactor.
	There is an open circuit in the vacuum motor wiring.	Check the vacuum motor wiring and connections from contactor **K5** to the motors, and the ground connections from the motors to battery ground. Repair as necessary.
	The vacuum current sensor (**B3**) is not operating correctly (generating a fault).	Check the wiring and connections from the A1 Main Machine Controller to the vacuum current sensor and repair as necessary.
		Check the +5V output from **J7-24** and the ground output from **J7-25** to the vacuum current sensor (**B3**) from the A1 Main Machine Controller.
		Check the input to **J7-29** on the A1 Main Machine Controller from the vacuum current sensor. If the output is not between 2.5 and 4.7 volts, replace the vacuum current sensor.

Problem	Cause	Correction
An individual vacuum motor will not run.	No voltage to the vacuum motor.	Check the wiring and connections to the vacuum motor and repair as necessary.
	The motor is not operating correctly.	If there is voltage to the vacuum motor, replace the motor.
Poor water pick-up.	There is a vacuum leak between the squeegee weldment and the recovery tank.	• Make sure the squeegee hose is installed correctly in the recovery tank and on the squeegee weldment. • Check the squeegee hose for blockage, damage or cracks and repair/replace as necessary.
	The squeegee is plugged.	• Check the squeegee and clean/repair as necessary.
	The squeegee blade(s) is/are worn out.	• Flip the squeegee blade(s) around to position a new blade surface on the floor. • Replace the squeegee blade(s).

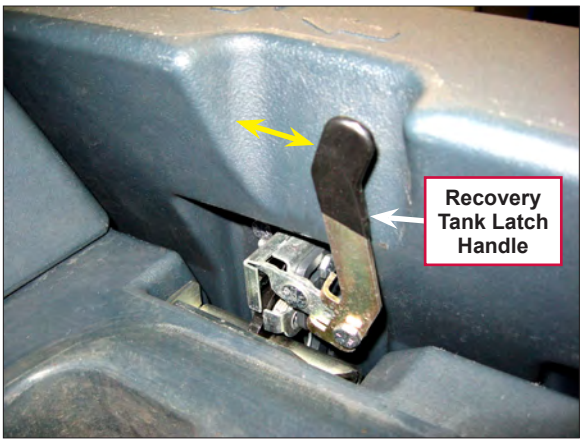
Removal and Installation

Warning! ***Before removing or reinstalling any machine components, make sure the key switch is off, the key is removed from the machine and the parking brake is engaged.***

To Remove the Recovery Tank

Caution: ***The recovery tank is relatively heavy. It's recommended that the recovery tank be removed by two or more persons to prevent possible personal injury or damage to the recovery tank.***

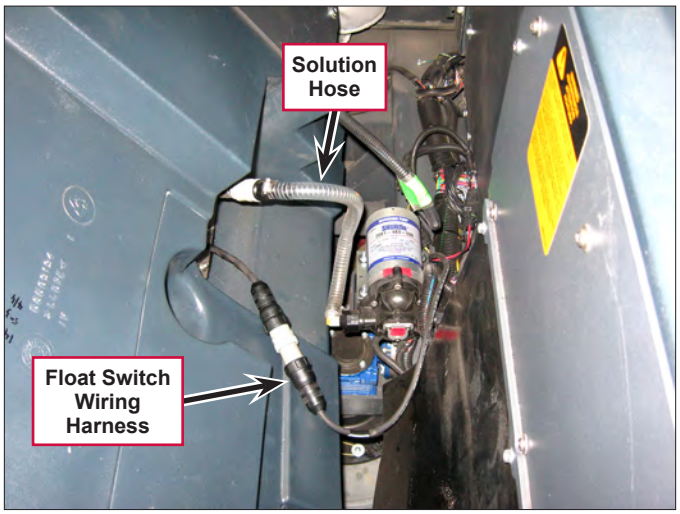
1. Drain the recovery tank.
2. Release the **Recovery Tank Latch Handle** and tip the tank away from the machine.
3. Remove the squeegee hose from the recovery tank.



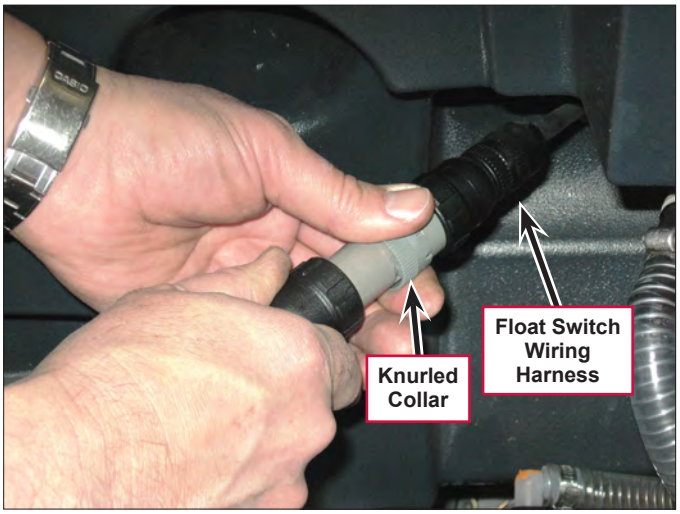
4. Disconnect the **Recovery Tank Vacuum Motor Electrical Connector**.

Note: *If your machine is equipped with an extended scrub system, you must disconnect the* ***Float Switch Wiring Harness*** *and* ***Solution Hose*** *before you can remove the recovery tank. These are described in steps 5 and 6.*

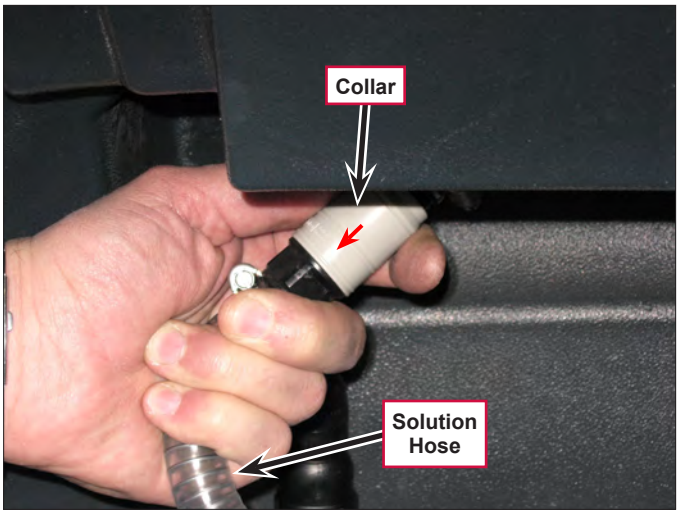
If your machine is not equipped with an extended scrub system, skip to step 7.



5. Loosen the **Knurled Collar** and disconnect the **Float Switch Wiring Harness**.

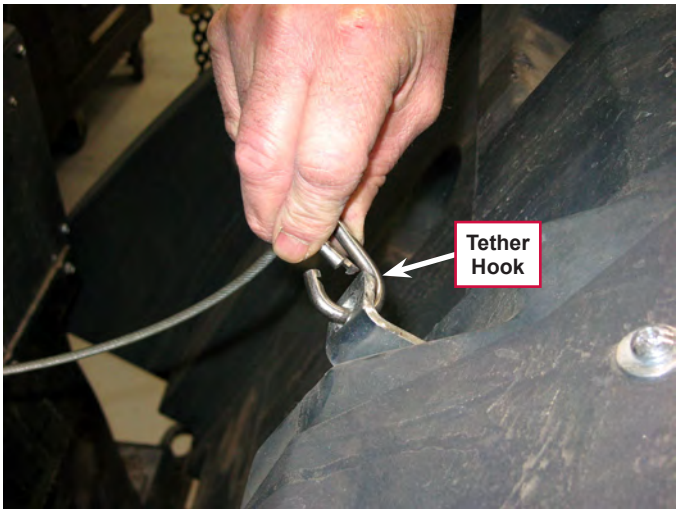


6. Pull the **Collar** on the quick-disconnect fitting and disconnect the **Solution Hose**.



7. Disconnect the **Tether Hook** and carefully tip and lift the recovery tank off of the mounting pins on the machine frame.

Service Note: *You may want to lay the recovery tank down onto a skid or other suitable platform on a pallet jack in order to more easily move the recovery tank once it's removed from the machine.*

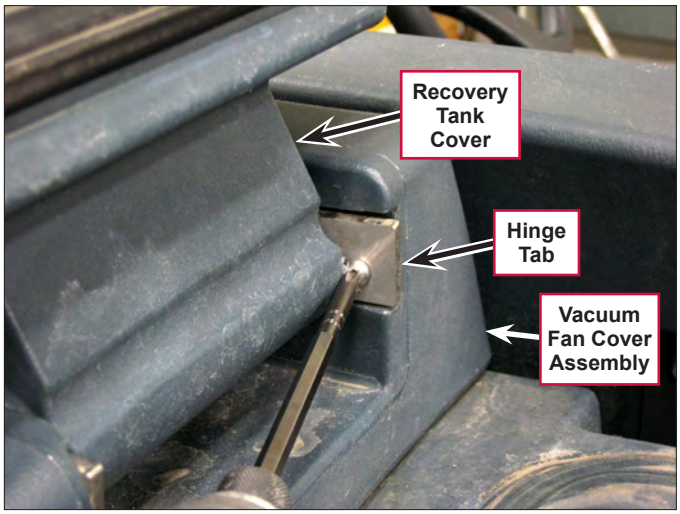


To Reinstall the Recovery Tank

1. Set the recovery tank onto the mounting pins on the machine frame.
2. Swing the recovery tank up and reattach the **Tether Hook** to the recovery tank.
3. Reconnect the recovery tank vacuum motor electrical connector.
4. Reconnect the extended scrub wiring harness and solution hose (if so equipped).
5. Reinstall the squeegee hose.
6. Swing the recovery tank up into position until the recovery tank latch handle engages.

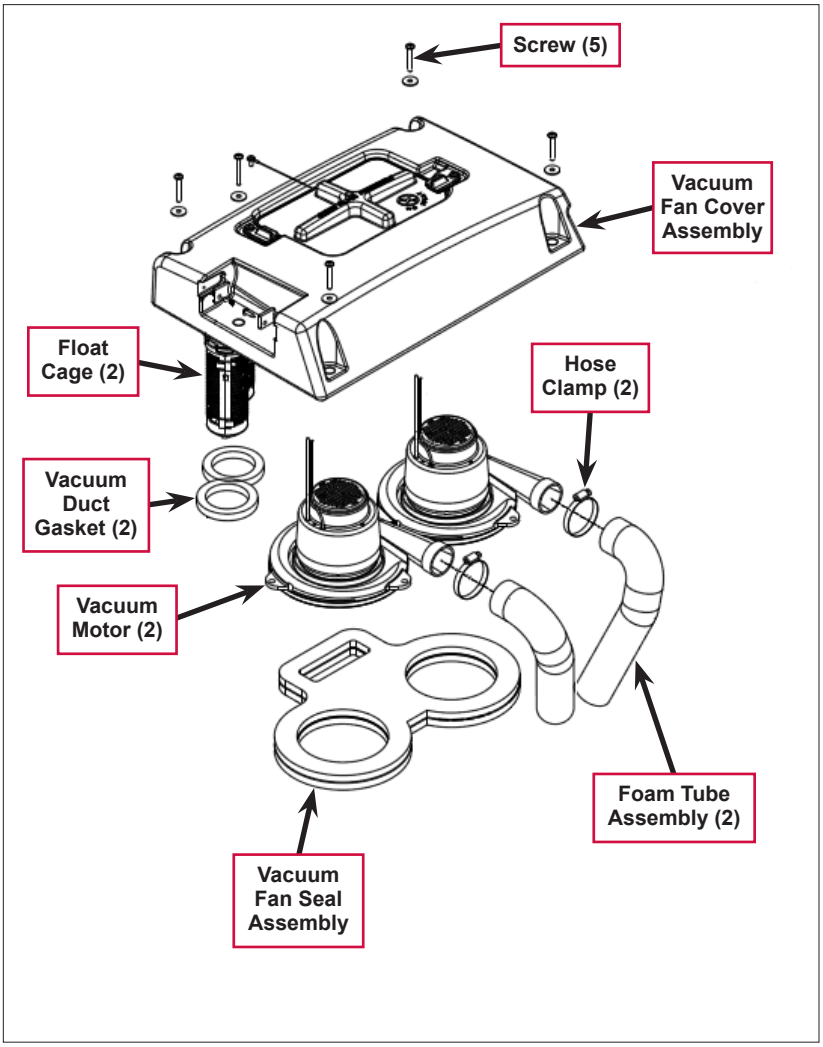
To Remove and Reinstall a Vacuum Motor

1. Lift up the **Recovery Tank Cover**.
2. Remove one of the **Hinge Tabs**, then twist and remove the **Recovery Tank Cover** from the **Vacuum Fan Cover Assembly**. This will allow access to the screw underneath the **Recovery Tank Cover** that holds the **Vacuum Fan Cover Assembly** to the recovery tank.



3. Remove the five **Screws** and washers holding the **Vacuum Fan Cover Assembly** to the recovery tank.
4. Carefully lift the **Vacuum Fan Cover Assembly** off of the recovery tank, making sure the **Float Cages** pass up through the cutouts in the tank.
5. Disconnect the **Vacuum Motor** electrical connector.
6. Loosen the **Hose Clamp** and disconnect the **Foam Tube Assembly** from the **Vacuum Motor**.
7. Carefully lift the **Vacuum Motor** out of the recovery tank.
8. Reinstall the **Vacuum Motor** by following the above steps in reverse order.

Note: *Before you reinstall a vacuum motor, check the **Vacuum Fan Seal Assembly** and the **Vacuum Duct Gaskets** for any wear or damage and replace if necessary.*



Specifications

Component	Specifications	
Vacuum Motor	Voltage - 42 VDC	
	Insulation Class - A	
	Current Draw	Average - 15 Amps
		Maximum - 17 Amps
Vacuum System	Vacuum	Sealed – 48” H_2O
		With 1” dia. Orifice – 25” to 30” H_2O

Special Tools

Vacuum water lift gauge, Nilfisk-Advance part number 56205281

Scrub System

Functional Description

Overview

The scrub system includes the scrub brushes, scrub brush motors, side squeegees, and the scrub deck actuator which lowers and raises the scrub deck.

The scrub deck actuator lowers the scrub brushes any time the scrub system is enabled. The brush motors switch on when the drive pedal is moved from the neutral position. The operator can enable the scrub system independent of the solution and recovery systems to scrub without adding or picking up solution.

Scrub Pressure Control

The electric scrub deck actuator motor (**M11**) moves the scrub deck up and down to control the scrub pressure. The retract limit switch (proximity sensor) (**S1**) stops the upward deck movement at the upper travel limit.

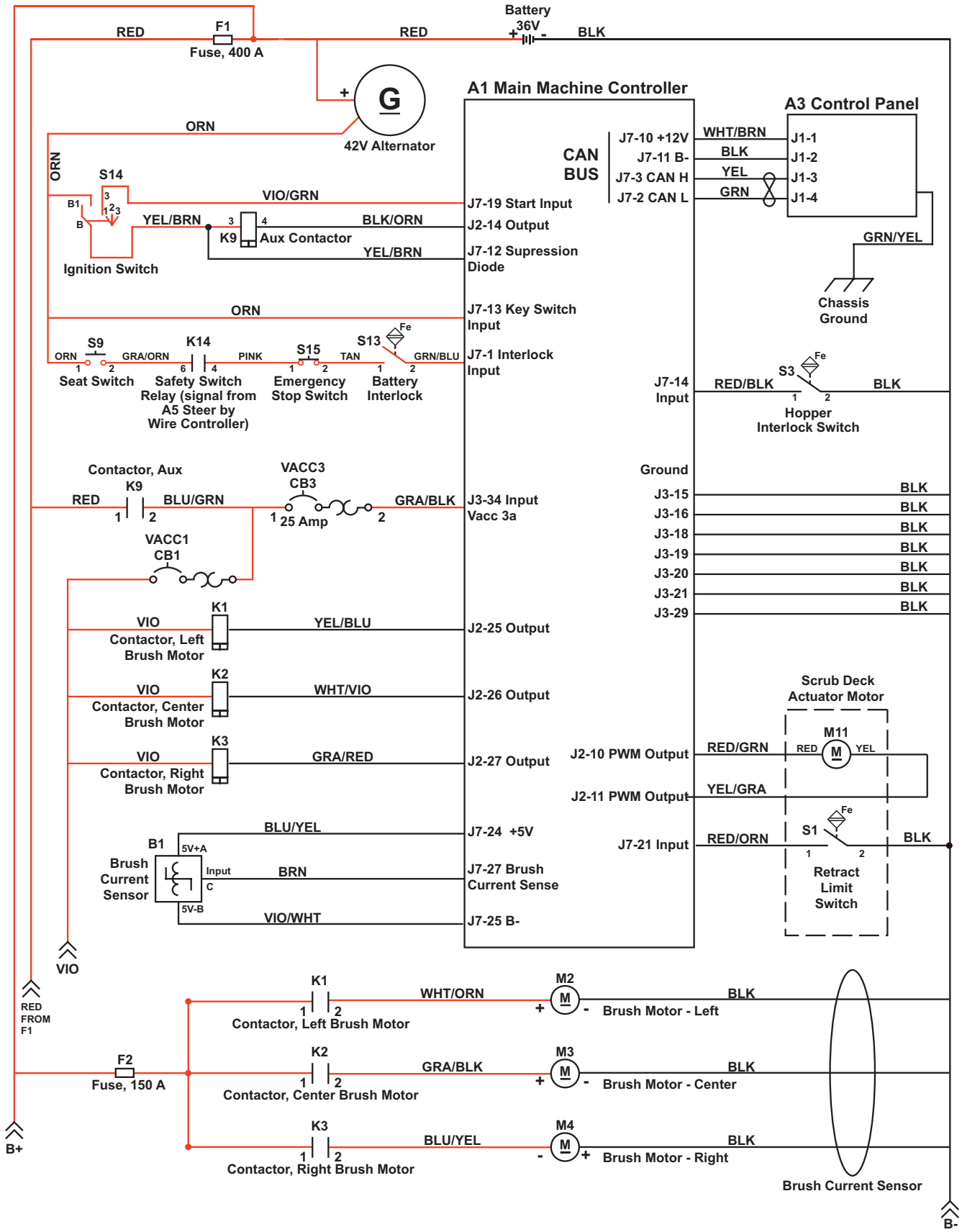
The brush current sensor (**B1**) acts like an “amp clamp” around the brush motor wires to constantly measure the total current draw of all three brush motors. This current reading is sent to the A1 Main Machine Controller on pin J7-27 Brush Current Sense. The A1 Main Machine Controller interprets this current value and raises or lowers the scrub deck as follows:

- If the brush motor current drops below the preset limits for the selected scrub pressure (1-3), the scrub deck actuator will lower the scrub deck to increase the scrub pressure and current draw until the current draw is again within the correct range.
- If the brush motor current rises above the preset limit for the selected scrub pressure, the scrub deck actuator will raise the scrub deck to decrease the scrub pressure and current draw until the current draw is again within the correct range.

The scrub brush current monitoring and scrub deck actuator allow the machine to automatically compensate for a variety of floor surfaces and scrubbing conditions while maintaining constant scrubbing pressure.

If the scrub deck actuator is unable to maintain the combined brush motor current draw below 75 amps for 25 seconds, or if there is a short circuit, the A1 Main Machine Controller will set an over-current fault code.

Scrub System Wiring Diagram



Circuit Description

The Following Conditions Must be Met for the Scrub System To Operate

- The **Hopper Interlock Switch S3** must be closed.
- There must be positive voltage to the **J7-1 Interlock Input**. For this to happen:
  - The **Seat Switch S9** must be closed.
  - The **Safety Relay K14** on the **Steer By Wire Controller A5** must energize the coil to close the **Safety Relay K14** contactor.
  - The **Emergency Stop Switch S15** must be closed.
  - The **Battery Interlock S13** must be closed.
- The **400-amp Fuse F1** must be closed to provide positive voltage from the **Battery** to the load side of **Auxiliary Contactor K9**.
- The **Ignition Switch S14** must be closed to provide positive voltage to the **Auxiliary Contactor K9** coil. The **J2-14 Output** on the **A1 Main Machine Controller** provides ground to the **Auxiliary Contactor K9** coil when the **Ignition Switch S14** provides an input to the **Key Switch Input J7-13**.
- The **Auxiliary Contactor K9** must be closed to provide positive voltage to circuit breakers **VACC1/CB1** and **VACC2/CB2**.
- Circuit breaker **VACC1/CB1** must be closed to provide positive voltage to **Solution Valve L1**.
- Circuit breaker **VACC2/CB2** must closed to provide positive voltage to the **Left Brush Motor Contactor K1**, the **Center Brush Motor Contactor K2** and the **Right Brush Motor Contactor K3**.
- The **J2-25**, **J2-26** and **J2-27 Outputs** on the **A1 Main Machine Controller** must provide ground to the **Left Brush Motor Contactor K1** coil, the **Center Brush Motor Contactor K2** coil and the **Right Brush Motor Contactor K3** coil respectively. The **J2-25**, **J2-26** and **J2-27 Outputs** provide a ground under the following conditions:
  - The **A1 Main Machine Controller** must receive a signal from the **A3 Control Panel** via the CAN BUS that the operator has pressed the scrub switch.
  - The **A1 Main Machine Controller** must receive a signal from the **A2 Drive Controller** via the **CAN BUS** that the machine is moving forward or reverse.
- The **150-amp Fuse F2** must be closed to provide positive voltage from the **Battery** to the load side of **Contactors K1**, **K2** and **K3**.
- The **Brush Motors M2**, **M3** and **M4** must have connections to battery ground **B-**.

Scrub Deck Actuator Motor

- The **J2-10** and **J2-11 PWM Outputs** from the **A1 Main Machine Controller** provide voltage to the **Scrub Deck Actuator Motor M11**. The output polarity determines whether the **Scrub Deck Actuator Motor** lowers or raises the scrub deck.
- When the **Retract Limit Switch S1** closes, it connects the **J7-21 Input** to ground which signals the **A1 Main Machine Controller** that the scrub deck has reached its upper limit. The **A1 Main Machine Controller** will switch off the **J2-10** and **J2-11 PWM Outputs** to stop the upward scrub deck travel.

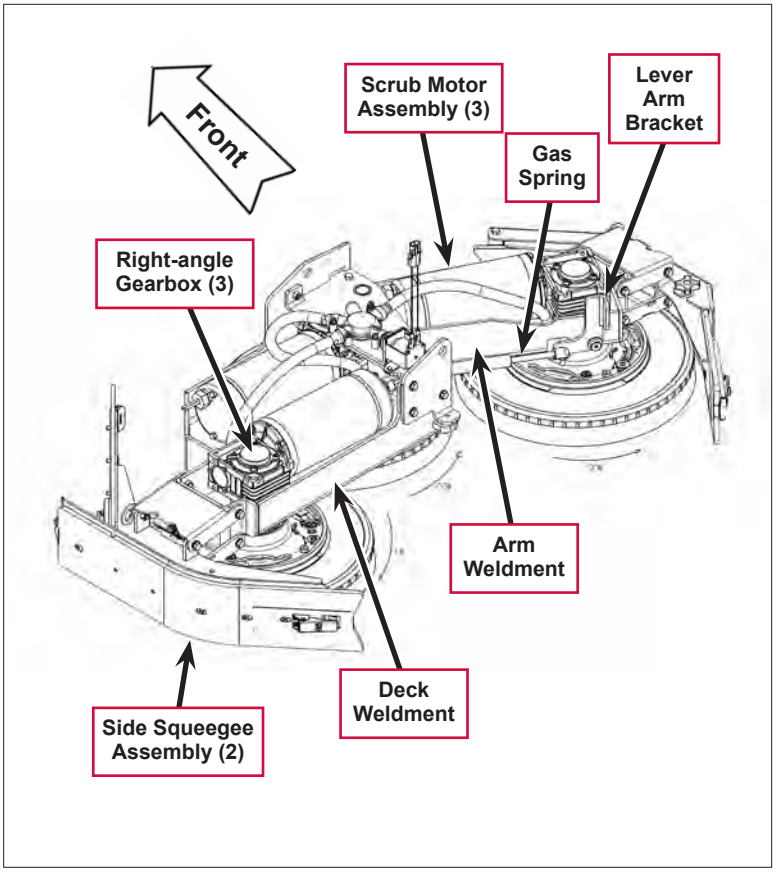
Brush Current Sensor

- **J7-24** provides +5 volts to the **Brush Current Sensor**.
- **J7-25** provides battery ground (**B-**) to the **Brush Current Sensor**.
- The Input from the **Brush Current Sensor** provides the **Brush Current Sense** signal to **J7-27** on the A1 Controller Board. The A1 Controller Board uses this current value to run the **Scrub Deck Actuator Motor M11** in the appropriate direction to either raise or lower the scrub deck to maintain the total scrub motor current draw within the prescribed range for the selected scrub pressure.

Component Locations

Scrub Motor Assemblies

The left-hand and center **Scrub Motor Assemblies** are mounted on the **Deck Weldment**. The right-hand **Scrub Motor Assembly** is mounted on the **Arm Weldment** bolted to the **Deck Weldment**. The **Right-angle Gearboxes** are mounted on spacers to position them correctly on the **Deck** and **Arm Weldments**.



Right Scrub Arm Gas Spring and Lever Arm Bracket

The **Gas Spring** keeps the right **Arm Weldment** and attached **Side Squeegee Assembly** extended outward during normal scrubbing, but will allow the **Arm Weldment** to pivot backward if the right-hand **Side Squeegee Assembly** hits an object or obstacle. This provides some compliance to prevent damage to the **Side Squeegee Assembly**.

To release the **Gas Spring** to pivot the right **Arm Weldment** backward for service or maintenance proposes, pull the top of the **Lever Arm Bracket** toward you and swing the **Arm Weldment** backward.

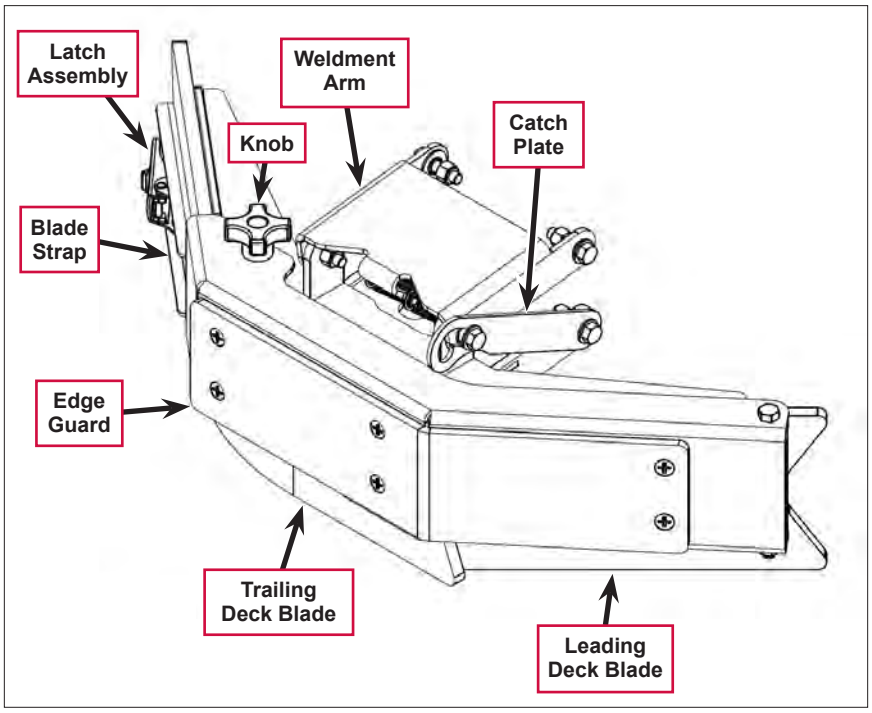
Side Squeegee Assemblies

The **Side Squeegee Assemblies** are mounted to **Weldment Arms** that are attached to the **Deck/Arm Weldments**. The **Side Squeegee Assemblies** are spring-loaded to keep them firmly on the floor. A **Catch Plate** allows you to lock the **Side Squeegee Assemblies** in the upper position for double-scrub cleaning and maintenance.

An **Edge Guard**, held in position by a **Knob**, protects the right-hand **Side Squeegee Assembly** and swings out to allow access to the **Blade Strap** and **Trailing Deck Blade**.

The **Latch Assembly** releases to allow you to remove the **Blade Strap** and **Trailing Deck Blade**.

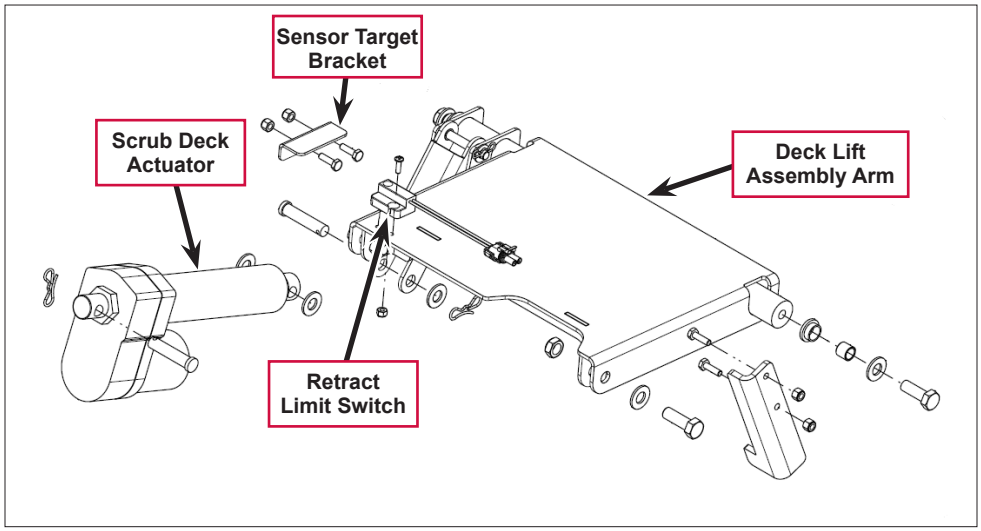
The **Leading Deck Blades** are held in place by strap weldments and wing knobs.



Scrub Deck Actuator

The **Scrub Deck Actuator** is pinned to the machine frame, and to the pivoting **Deck Lift Assembly Arm**. When the **Scrub Deck Actuator** extends or retracts, it lowers or lifts the free side of the **Deck Lift Assembly Arm**.

The **Deck Lift Assembly Arm** pivots on flange bearings and bushings in the frame to raise and lower the attached scrub deck. Note that the scrub deck is free to "float" left-to-right to conform to the floor surface.



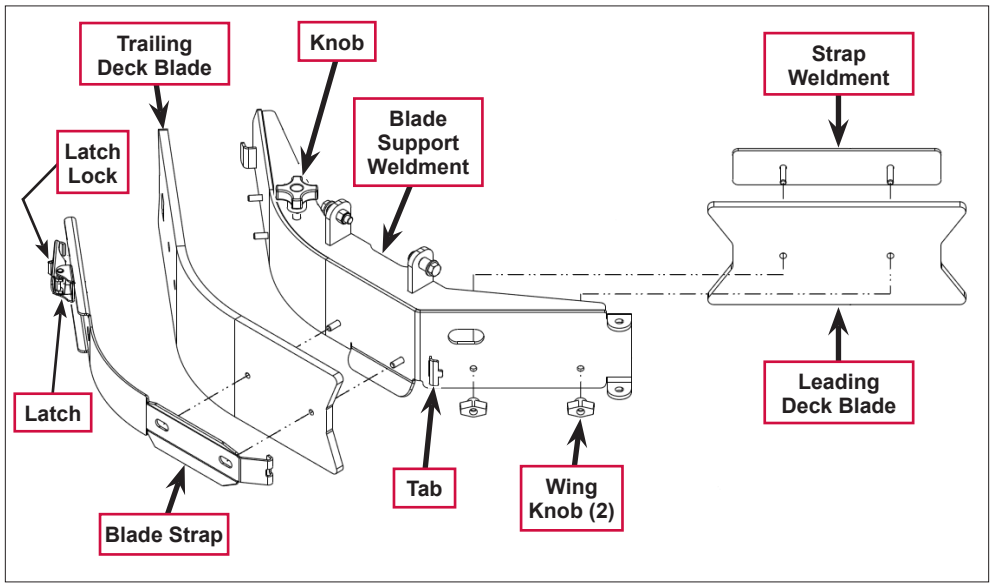
The **Retract Limit Switch S1** will detect the **Sensor Target Bracket** when the scrub deck is fully retracted upward and stop the **Scrub Deck Actuator** motor.

Maintenance and Adjustments

Warning! ***Before performing any machine maintenance or adjustments, make sure the key switch is off, the key is removed from the machine and the parking brake is engaged.***

To Replace a Leading Deck Blade

1. Loosen the **Knob** and swing out the edge guard (not shown - on right-hand side squeegee assembly only).
2. Remove the two **Wing Knobs**.
3. Remove the **Strap Weldment** and **Leading Deck Blade** from inside of the **Blade Support Weldment**.
4. Reverse the existing **Trailing Deck Blade** to position a new blade surface on the floor, or install a new **Trailing Deck Blade** onto the **Strap Weldment** pins as shown.



5. Install the **Trailing Deck Blade** and **Strap Weldment** on the inside of the **Blade Support Weldment**, then reinstall and tighten the two **Wing Knobs**.
6. Swing the edge guard back into position, then tighten the **Knob** (right-hand side squeegee assembly only).

To Replace a Trailing Deck Blade

1. Loosen the **Knob** and swing out the edge guard (not shown - on right-hand side squeegee assembly only).
2. Press the **Latch Lock**, open the **Latch** and remove the **Blade Strap** and **Trailing Deck Blade** from the **Blade Support Weldment**.
3. Reverse the existing **Trailing Deck Blade** to position a new blade surface on the floor, or install a new **Trailing Deck Blade** onto the **Blade Support Weldment** pins as shown.
4. Hook the end of the **Blade Strap** into the matching **Tab** on the **Blade Support Weldment**.
5. Wrap the **Blade Strap** over the **Trailing Deck Blade** and close the **Latch**.

Troubleshooting

Note: *You can use the Service Mode to toggle the various system components on and off to check for function. Refer to the* ***Control System/Service Mode*** *section for information on how to enter and use the Service Mode.*

Problem	Cause	Correction
The scrub system does not operate.	An interlock is not closed.	Before you start troubleshooting the scrub system, check to make sure: • The emergency stop switch (**S15**) on the Operator control panel is disengaged (rotate clockwise). • The safety relay from the steering system (**K14**) is closed. • The seat switch (**S9**) is closed. • The battery interlock proximity sensor (**S13**) is closed. • The A1 Main Machine Controller is receiving the appropriate signal from the A3 Control Panel via the CAN BUS.
None of the scrub deck motors will run.	The 150-amp Fuse (**F2**) is blown.	Check the Fuse (**F2**) and replace if necessary.
	There is no voltage to the **K1**, **K2** and **K3** contactor coils.	Check circuit breaker **CB1** and reset if necessary.
		The contactor **K9** is not providing positive voltage to the **K1**, **K2** and **K3** contactor coils. 1. Check the **K9** contactor coil resistance. If the coil resistance is not 118 ohms ± 10%, replace the contactor. 2. Check the continuity through contactor **K9** with the coil energized. If the contacts are open, replace the contactor. 3. Check the **J2-14** output from A1 Main Machine Controller.
An individual scrub deck motor will not run.	There is no voltage to the corresponding contactor coil (**K1**/**K2**/**K3**).	1. Check the coil resistance in the **K1**/**K2**/**K3** contactor coil. If the coil resistance is not 118 ohms ± 10%, replace the contactor. 2. Check the continuity through contactor **K1**/**K2**/**K3** with the coil energized. If the contacts are open, replace the contactor. 3. Check the **J2-25**/**J2-26**/**J2-27** output from A1 Main Machine Controller.
	There is an open circuit in the scrub motor wiring.	Check the motor wiring and connections from contactor **K1**/**K2**/**K3** to the motor, and the ground connection from the motor to battery ground. Repair as necessary.
	The motor is not operating correctly.	Replace the scrub deck motor.
The scrub deck actuator is not raising and lowering the deck.	There is an open circuit in the deck actuator motor wiring.	Check the wiring and connections from the A1 Main Machine Controller to the scrub deck actuator motor and repair as necessary.
	There is no voltage output from the A1 Main Machine Controller.	Check the output from **J2-10** and **J2-11** from the A1 Main Machine Controller.

Problem	Cause	Correction
The scrub deck actuator will not raise the deck.	The retract limit switch (**S1**) is shorted out.	Check the switch function and replace if necessary. Note that the retract limit switch is a proximity switch should be closed when close to the metal
The scrub pressure is inconsistent.	The brush current sensor (**B1**) is not operating correctly.	Check the wiring and connections from the A1 Main Machine Controller to the brush current sensor and repair as necessary.
		Check the +5V output from **J7-24** and the ground output from **J7-25** to the brush current sensor (**B1**) from the A1 Main Machine Controller.
		Check the input to **J7-27** on the A1 Main Machine Controller from the brush current sensor. If the output is not between 2.5 and 4.7 volts, replace the brush current sensor.

Removal and Installation

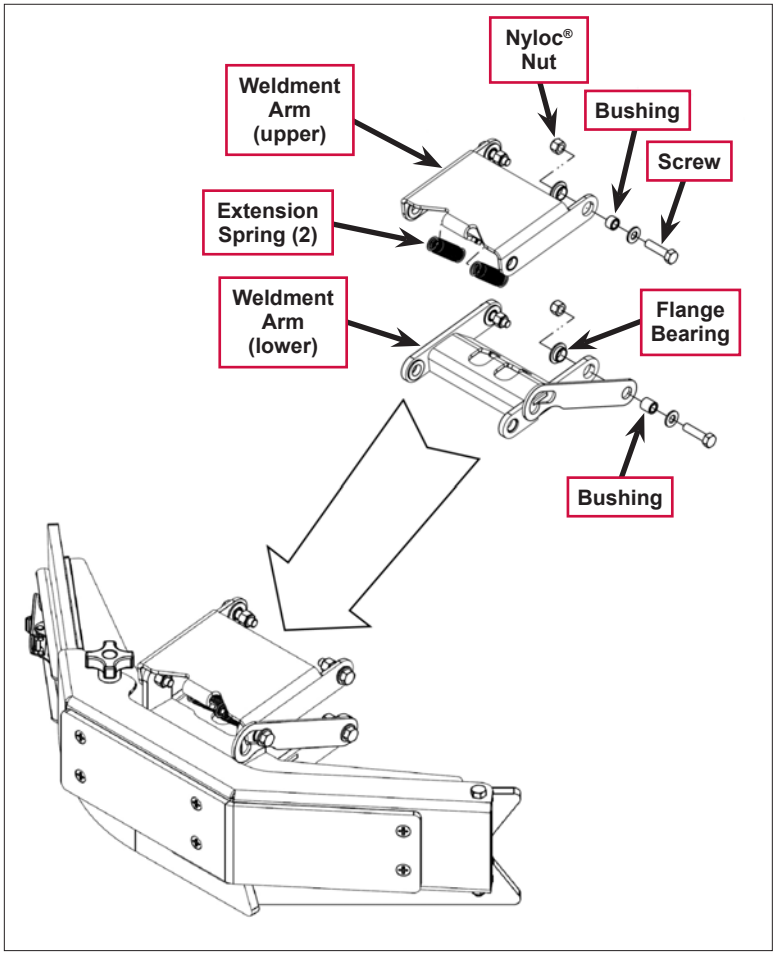
Warning! Before removing or reinstalling any machine components, make sure the key switch is off, the key is removed from the machine and the parking brake is engaged.

To Remove and Reinstall a Side Squeegee Assembly

1. Loosen the knob and swing out the edge guard.
2. Carefully remove the **Extension Springs** from the tabs on the upper **Weldment Arm**.
3. Remove the **Screws**, washers, **Bushings**, **Flange Bearings** and **Nyloc® Nuts** holding the side squeegee assembly to the scrub deck, then remove the side squeegee assembly from the machine.

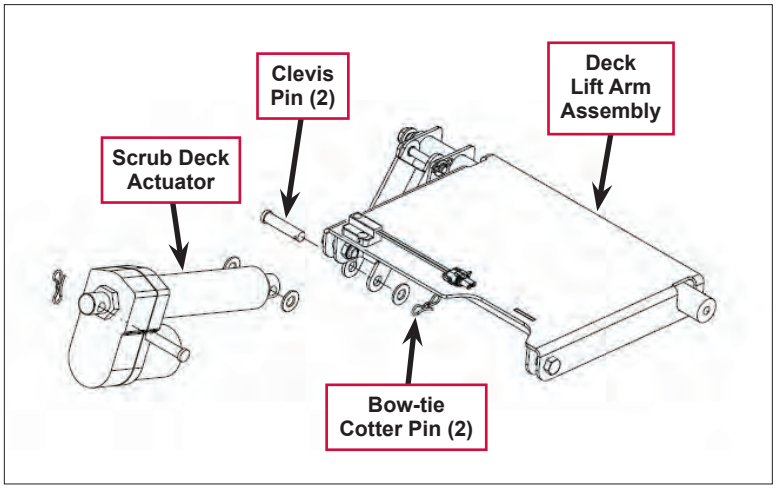
Note: *The **Bushings** in the upper and lower **Weldment Arms** are different. Make sure to note where the hardware items are located as you remove the squeegee assembly to ensure the mounting hardware is reinstalled correctly.*

4. Reinstall the side squeegee assembly by following the above steps in reverse order.



To Remove and Reinstall the Scrub Deck Actuator

1. Remove the recovery tank (refer to the ***Recovery System*** section).
2. Turn on the key switch and put the machine into the Service Test mode to allow you to jog the scrub deck up and down.
3. Extend the scrub deck downward in the Service Test mode to minimize the weight on the **Scrub Deck Actuator**.
4. Disconnect the **Scrub Deck Actuator** electrical connector
5. Remove the **Bow-tie Cotter Pin**, washers and **Clevis Pin** holding the **Scrub Deck Actuator** to the **Deck Lift Arm Assembly**.
6. Remove the **Bow-tie Cotter Pin** and **Clevis Pin** holding the **Scrub Deck Actuator** to the machine frame, then remove the **Scrub Deck Actuator** from the machine.



7. Reinstall the **Scrub Deck Actuator** by following the above steps in reverse order.

To Remove and Reinstall the Scrub Deck

1. Remove the recovery tank (refer to the ***Recovery System*** section).
2. Make sure the solution shutoff valve is closed, then disconnect the solution hose to the solution solenoid valve.
3. Turn on the key switch and put the machine into the Service Mode to allow you to jog the scrub deck up and down.

4. Disconnect the **Electrical Connectors** to the three **Scrub Motors**, to the **Proximity Sensor** on the **Deck Lift Arm Assembly** and to the **Solution Solenoid Valve**. Jog the **Scrub Deck** up or down as necessary to access the **Electrical Connectors**. Note that you may need to cut wire ties to access the **Electrical Connectors**.

5. Extend the scrub deck downward in the Service Test mode to minimize the weight on the **M12-1.75 x 35mm Screws** supporting the **Deck Lift Arm Assembly** and **Scrub Deck**.

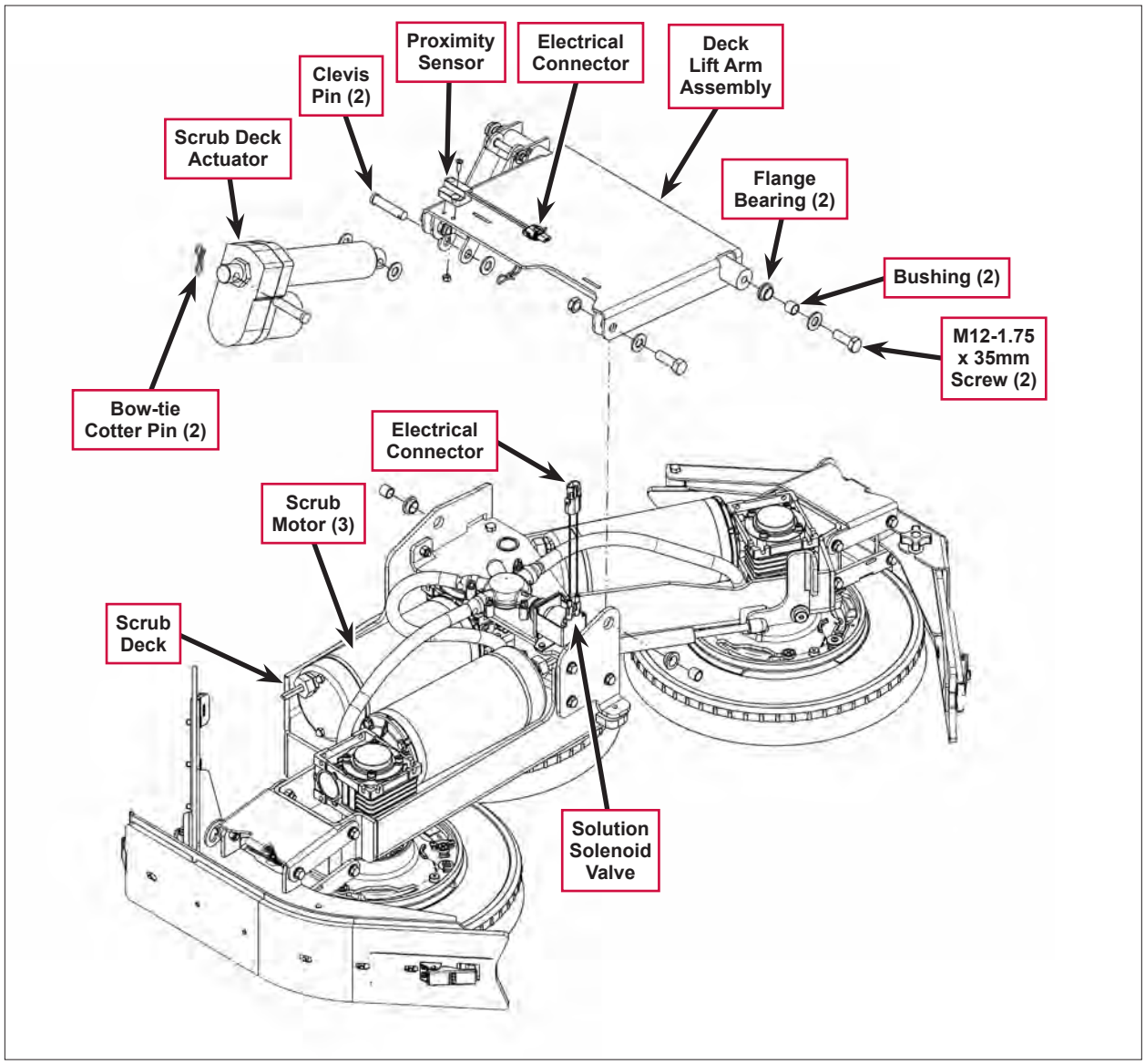
6. Remove the two **M12-1.75x 35mm Screws**, washers, **Bushings** and **Flange Bearings** holding the **Deck Lift Arm Assembly** and attached **Scrub Deck** to the machine frame.

7. Remove the **Bow-tie Cotter Pin**, washers and **Clevis Pin** holding the **Scrub Deck Actuator** to the **Deck Lift Arm Assembly**.

8. Jack the machine up as necessary to get enough clearance to remove the **Scrub Deck**, then support the machine with jack stands.

Warning! Never work under a machine without safety stands or blocks to support the machine. When jacking the machine, do so at the designated Tie Down/Jacking Locations.

9. Slide the **Scrub Deck** and attached **Deck Lift Arm Assembly** out from under the machine.



10. Reinstall the **Scrub Deck** by following the above steps in reverse order.

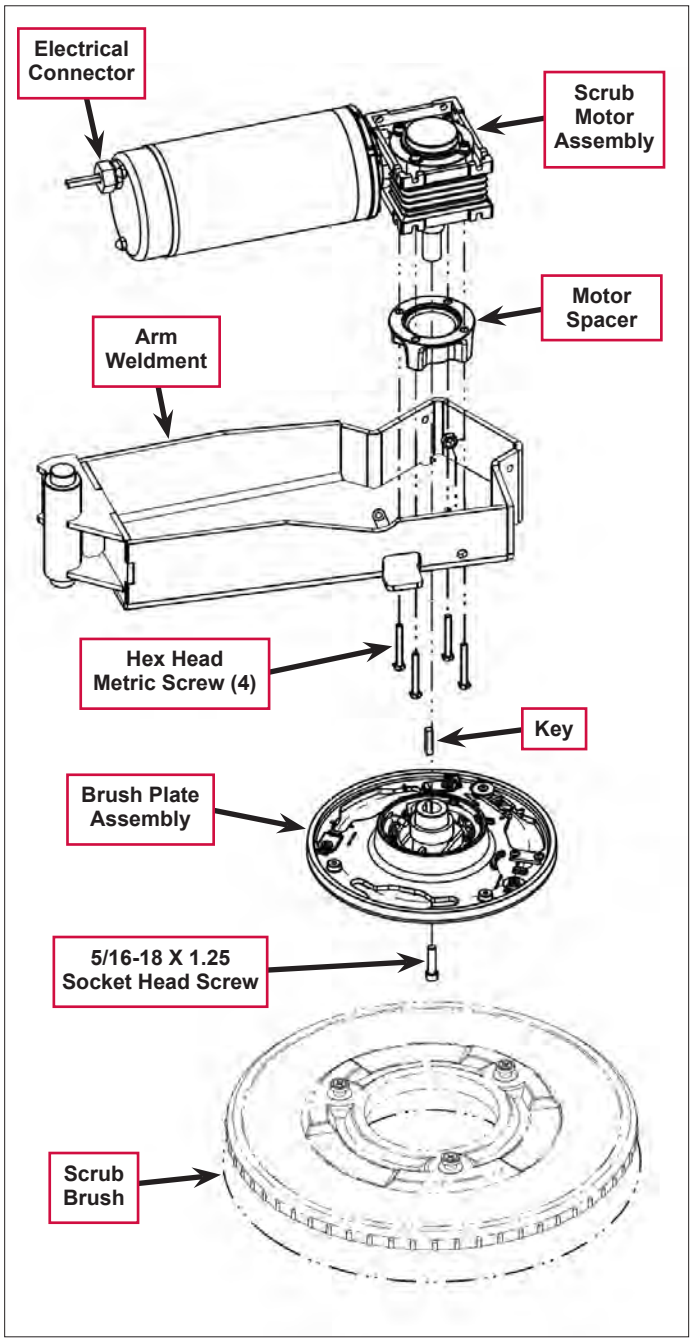
Service Note: *When you reinstall the* **Scrub Deck***:*

- *Make sure you reconnect the* **Scrub Motors** *to the correct* **Electrical Connectors** *in the wire harness as follows:*
  - *Left scrub motor - White/Orange wire*
  - *Center scrub motor - Gray/Black wire*
  - *Right scrub motor - Blue/Yellow wire*
- *Make sure the two* ***Flange Bearings*** *are installed in the machine frame through holes, and that the* ***Bushings*** *and washers are installed correctly before installing the two* ***M12-1.75x 35mm Screws****.*
- *You may find it easier to use a tapered punch or other suitable tool to align the* ***Bushings****,* ***Flange Bearings*** *and* ***Deck Lift Arm Assembly*** *with the through holes in the frame before you install the* ***M12-1.75x 35mm Screws****.*

To Remove and Reinstall a Scrub Motor Assembly

1. Remove the scrub deck from the machine.
2. Disconnect the electrical connector from the **Scrub Motor Assembly**.
3. Remove the **Scrub Brush** from the **Brush Plate Assembly**.
4. Remove the **5/16-18 X 1.25 Socket Head Screw** from the gearbox shaft and carefully remove the **Brush Plate Assembly**.
5. Remove the four **Hex Head Metric Screws**, then lift the **Scrub Motor Assembly** and **Motor Spacer** off of the **Arm Weldment** (shown) or deck weldment.
6. Reassemble the **Scrub Motor Assembly** following the above steps in reverse order.

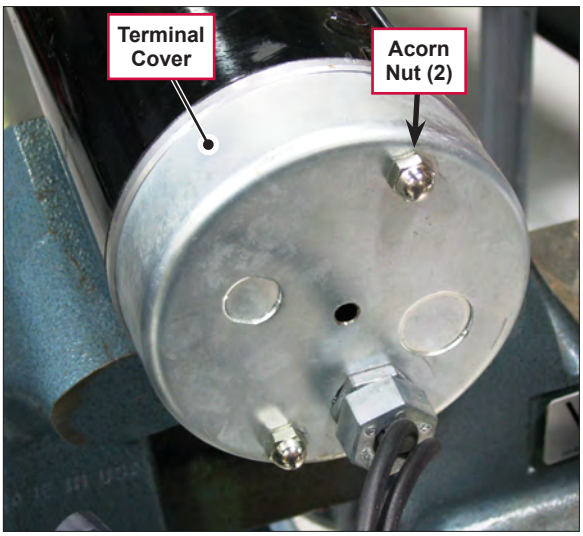
Note: *Make sure the **Key** is installed correctly before you reinstall the **Brush Plate Assembly** onto the scrub motor shaft.*



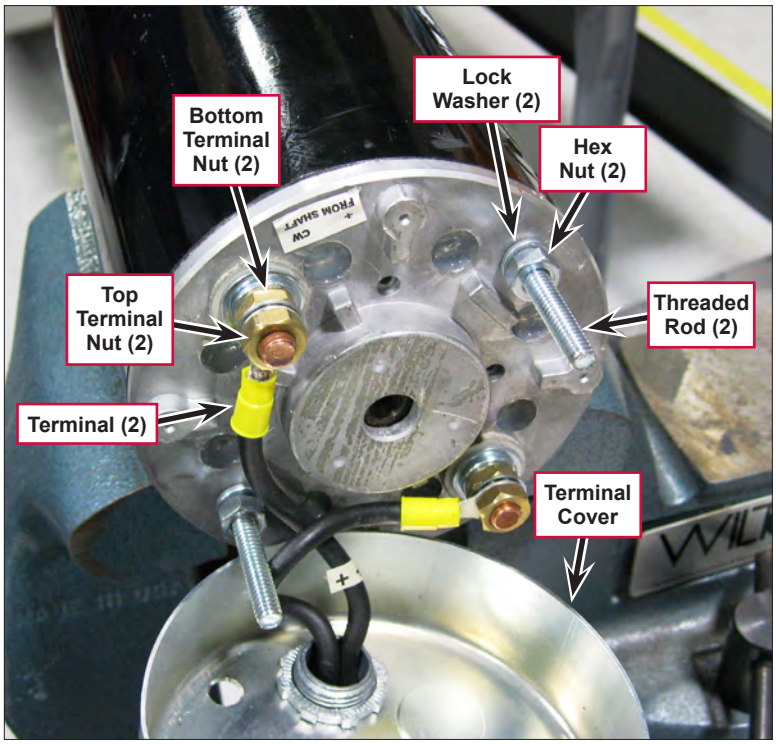
To Replace the Scrub Motor Carbon Brushes

Note: *The minimum length of the carbon brushes in the scrub motors is 0.5" [13 mm]. If the carbon brushes are less than 0.5" [13 mm] long, replace them.*

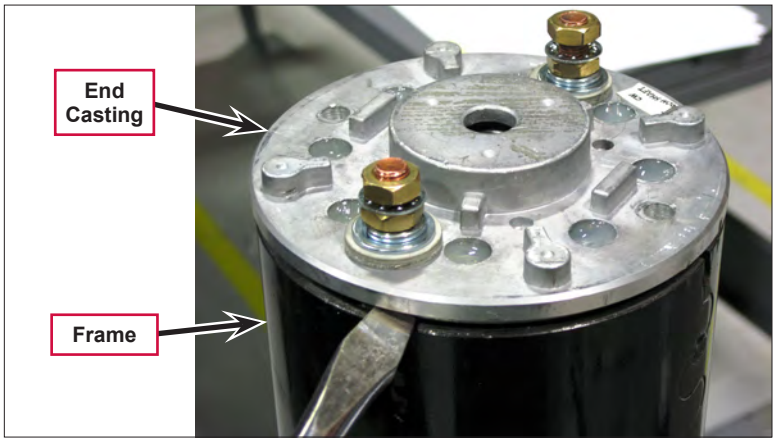
1. Remove the scrub motor assembly from the scrub deck.
2. Remove the scrub motor from the right-angle gearbox.
3. Note the position of the witness marks stamped into the frame and castings on both ends of the motor.
4. Remove the two **Acorn Nuts** and open the **Terminal Cover**.



5. Use a backup wrench to hold the **Bottom Terminal Nuts** in place, then remove the **Top Terminal Nuts** and **Terminals**. Make sure to note the wire polarity.
6. Remove the **Terminal Cover**.
7. Remove the **Hex Nuts**, **Lock Washers** and **Threaded Rods** holding the two end castings to the **Frame**.



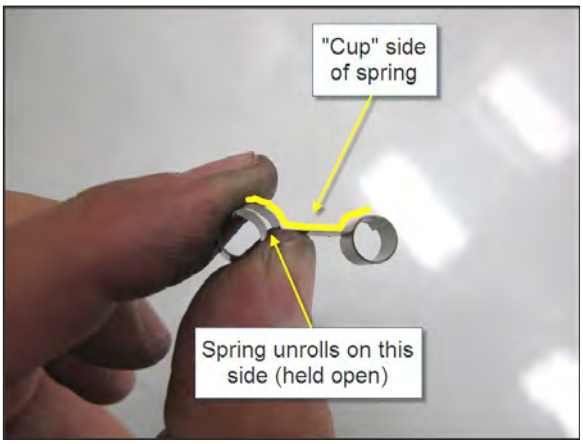
8. Carefully pry the **End Casting** from the **Frame**. Be careful not to lose the wave washer between the **End Casting** and the motor bearing.



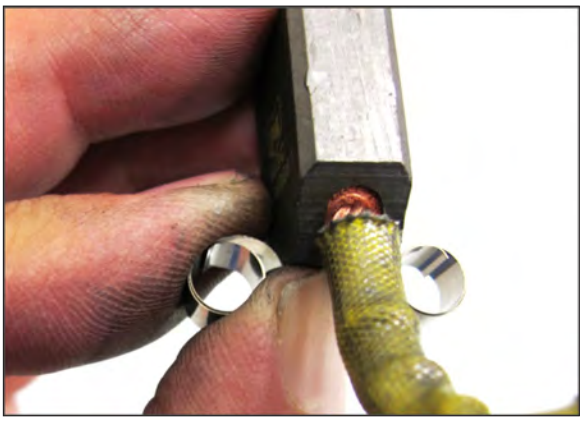
9. Replace the carbon brushes as follows:

   a. Observe how the springs roll when the brush is pushed back before taking it apart.

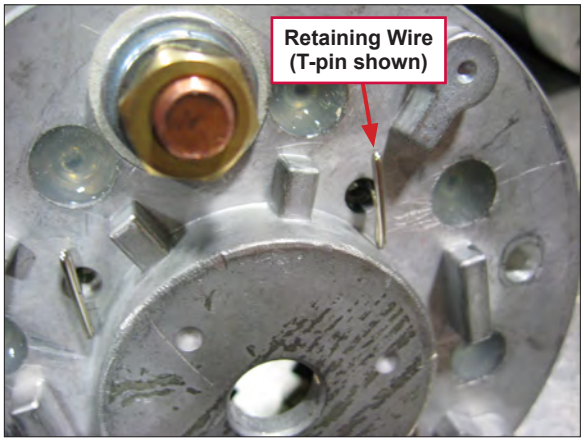
   b. Remove a brush and spring.

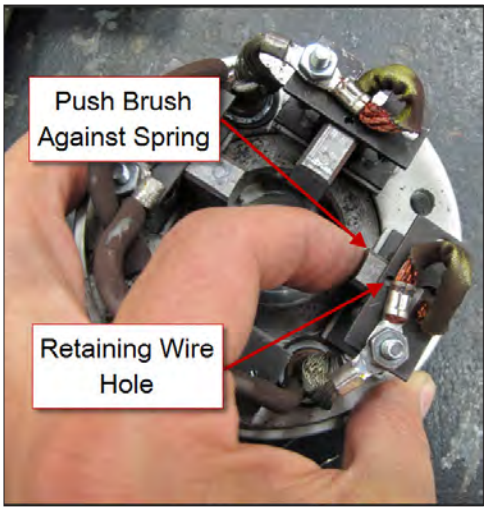


   c. Install a new brush and spring into the brush holder. Thread the brush wire lead through the brush holder. Position the back end of the brush in the “cup” of the spring so that the spring will unroll as the brush is pushed back once it is installed.

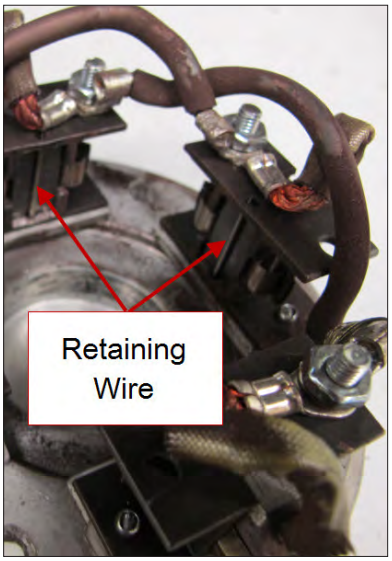


d. Push the **Brush** back against the spring and insert a stiff temporary **Retaining Wire** (paper clip or **T-pin**) through the access hole in the end cover. (Remove silicone sealer from the holes.) The wire must go through the holes in the brush holder just in front of the **Brush** to hold the **Brush** back against the spring pressure.

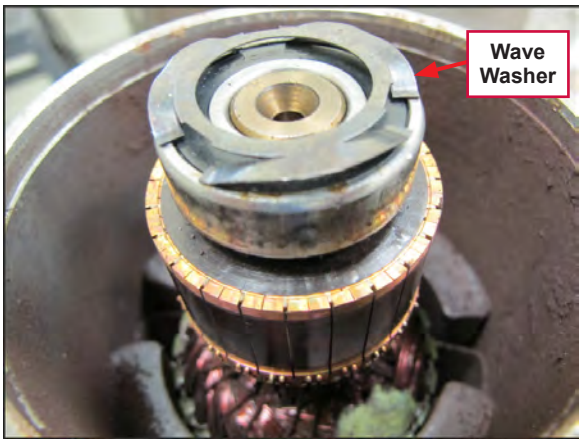




10. Install the other three **Brushes**.



11. Reinstall the **Wave Washer**. Make sure the bottom edges of the **Wave Washer** contact the outside bearing race as shown.



12. Reinstall the end casting in stages as follows.

    a. Reinstall the end casting with brushes far enough into the frame so the brushes will contact the commutator when the temporary retaining wires are removed, then remove the retaining wires.

    b. Press the end casting into the frame, leaving about a 1/8” gap between the frame and end casting. Make sure to align the witness marks on the end casting and frame as noted in step 3.

    c. Reinstall the threaded rods, lock washers and hex nuts, but don’t tighten the hex nuts yet.

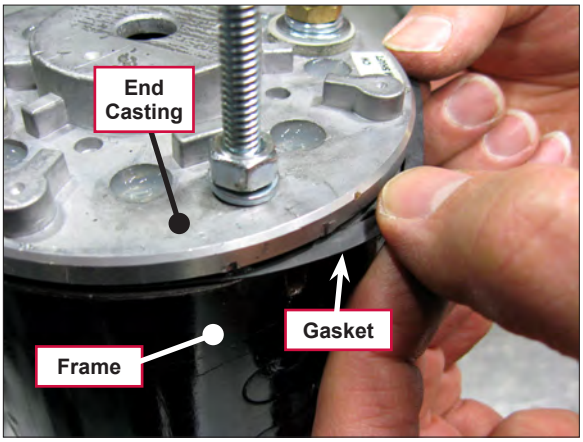
d. Carefully install a new **Gasket** between the **Frame** and the **End Casting**. Make sure the **Gasket** is seated flat on the mating surfaces.

e. Once the **Gasket** is installed, fully seat the **End Casting** onto the **Frame**.

f. Tighten the hex nuts.

13. Reinstall the terminals and top terminal nuts, then reinstall the terminal cover and acorn nuts.

14. Seal the retaining wire holes in the end cover with silicone sealant.



Specifications

Component	Specifications		
Scrub Brush Motors (all)	35 VDC, 1 HP, 2750 RPM, 26 Amp		
Scrub Brush Motor - Center	Current Draw (shop measurements)	Average - 19 Amps	Max. - 37 Amps
Scrub Brush Motor - Left	Current Draw (shop measurements)	Average - 17 Amps	Max. - 23 Amps
Scrub Brush Motor - Right	Current Draw (shop measurements)	Average - 17 Amps	Max. - 26 Amps
Deck Actuator Motor	Input Voltage - 34-40 VDC		
	Dynamic Load - 500 lbs. max.		
	Static Load - 1000 lbs. max.		
	Restraining Torque - 100 in.-lbs. min.		
	Current Draw	9 Amps max at rated dynamic load	
		2-5 Amps Typical	
	End of Stroke - Ball detent clutch with a load rating between 600 and 1000 lbs.; will ratchet at end of stroke		
	Thermal Protection - Automatic resetting thermal breaker enclosed in motor housing.		
	Wiring Polarity: • To extend actuator, connect red lead to positive and yellow lead to negative. • To retract actuator, connect yellow lead to positive and red lead to negative.		

Component	Specifications
Retract Limit Switch (Proximity Sensor)	Air Gap @ Make - .250 in. (typical)
	Air Gap @ Break - .313 in. (typical)
	Contact resistance (initial) - 150 milliohms max.

Special Tools

A spring puller is recommended to remove the Extension Springs from the Weldment Arms when removing the Side Squeegee Assemblies. There are several types of spring pullers - a typical example is shown here.	

Solution System

Functional Description

Overview

The solution system delivers water, or detergent and water, to the floor for the scrub system. The solution system includes the solution tank (main body of machine) and solution pressure (level) sensor, solution shutoff valve, solution filter, solution pump or pumps (some models), solution solenoid valve, and the associated plumbing to distribute solution to the nozzles at the three scrub brushes. A capped solution drain hose allows you to drain the solution tank.

The solution flows to the scrub brushes any time the scrub system is enabled, the scrub deck is lowered and the drive pedal is not in the neutral position. Programming options allow you to enable or disable solution flow when the machine moves in reverse. When the scrub system is disabled, no solution will flow to the brushes regardless of drive pedal or scrub deck position. The operator can enable the solution system independent of the scrub system to pre-wet the floor before enabling the scrub and/or recovery systems.

Solution Flow Control - Non-EcoFlex™ Machines

On the non-EcoFlex™ machines, an electrically-activated solenoid valve controls the solution flow. The solution is gravity-fed to the solenoid valve, and the solenoid valve output volume is controlled by the Main Controller through a PWM (pulsed width modulated) output. The A1 Main Machine Controller monitors the solution level via a solution pressure sensor. (Also refer to the ***Component Locations/Solution Tank/ Solution Pressure Sensor*** section.) As the solution level drops, the PWM output will increase to compensate for the loss of solution (head) pressure in order to maintain a consistent solution flow rate regardless of solution level in the tank. The solution solenoid's coil circuit opens and closes (pulsing on and off), pulling the valve diaphragm on and off its seat. This way the A1 Main Machine Controller can manage the three different auto flow volumes and two different override flow rates.

On non-EcoFlex™ machines, the operator must manually mix the detergent with the water in the solution tank if detergent is desired in the solution.

Solution Valve Desired Flow per Solution Setting	
Solution Flow Setting	Desired Flow (GPM)
1	1.0
2	1.5
3	2.0
4	2.5
5	3.0

Solution Flow Control - EcoFlex™ Machines

EcoFlex™ models use a solution control pump (**M19**) to supply the solution to the scrub brushes. On EcoFlex™ machines, the solution solenoid valve remains open when the solution control pump is running and the solution flow is controlled by the pump output. This allows more precise mixing of the detergent/ water mix to the brushes. The EcoFlex™ detergent delivery line is plumbed into the solution line between the solution pump and the solution solenoid valve.

EcoFlex™ Detergent System

The EcoFlex™ detergent system uses dual diaphragm pumps (**M17** and **M18**) to pump detergent into the solution flow upstream of the solution solenoid valve. Two detergent pumps are used when necessary to ensure adequate detergent supply at the higher detergent and solution flow rates. The detergent pumps receive PWM outputs from the A1 Main Machine Controller to regulate the detergent dispense rate according to the solution flow rate. The detergent supply line from the detergent bottle is split into two lines, one feeding each detergent pump. The two lines from the pumps merge into one line, which is then connected to the solution hose upstream of the solution solenoid valve.

Extended Scrub System

Machines equipped with the extended scrub system will pump the recovered water from the recovery tank to the scrub brushes when the solution tank is empty. The extended scrub system uses an additional pump (**M25**) to pump the recovered water to the scrub brushes. In order for the extended scrub system to work, the extended scrub system must be enabled, the solution tank low sensor must be actuated, and the float valve in the recovery tank must be closed to indicate adequate water level in the recovery tank. Note that when the machine is in the scrub mode:

- The solution pump will continue to run along with the extended scrub pump.
- The EcoFlex™ pumps will continue to add detergent to the recovered water.

Optional Hot Water System (LP and Diesel EcoFlex™ Machines Only)

On EcoFlex™ models equipped with the optional hot water system, the solution control pump pumps the solution to a heat exchanger. The heat exchanger is plumbed to the engine cooling system and uses the hot engine coolant to heat the solution as it circulates through the heat exchanger. The hot water system increases the solution temperature approximately 50 degrees F. The heated solution is then mixed with detergent and sent through the (open) solution solenoid valve and solution manifold to the brushes.

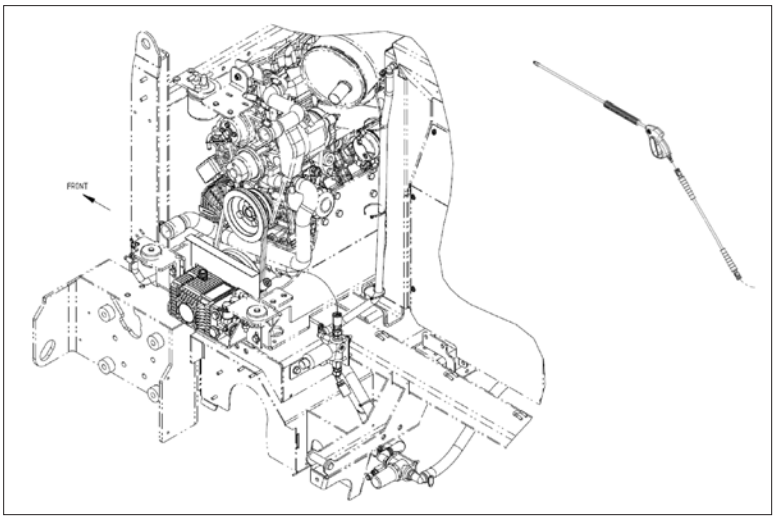
Note: *If your machine is equipped with a hot water system, do not add detergent to the solution tank as this can foul the heat exchanger.*

Optional Wash Hose Kit

The optional wash hose kit uses a separate low-pressure pump (**M23**) to pump solution from the solution tank to the hose and nozzle located behind the Operator seat. The wash hose kit operates independently and does not require the Operator to actuate the seat switch. A pressure switch on the low pressure pump will switch on the pump when the hose nozzle is opened and the solution pressure in the hose drops.

Optional High-pressure Spray System (LP and Diesel Only)

The optional high-pressure spray system uses a separate pump, driven by the engine via a clutch, to pump solution at high pressure from the tank to the hose and wand. The high-pressure spray system operates independently and has its own separate filter/strainer, and supply and return ports on the solution tank.



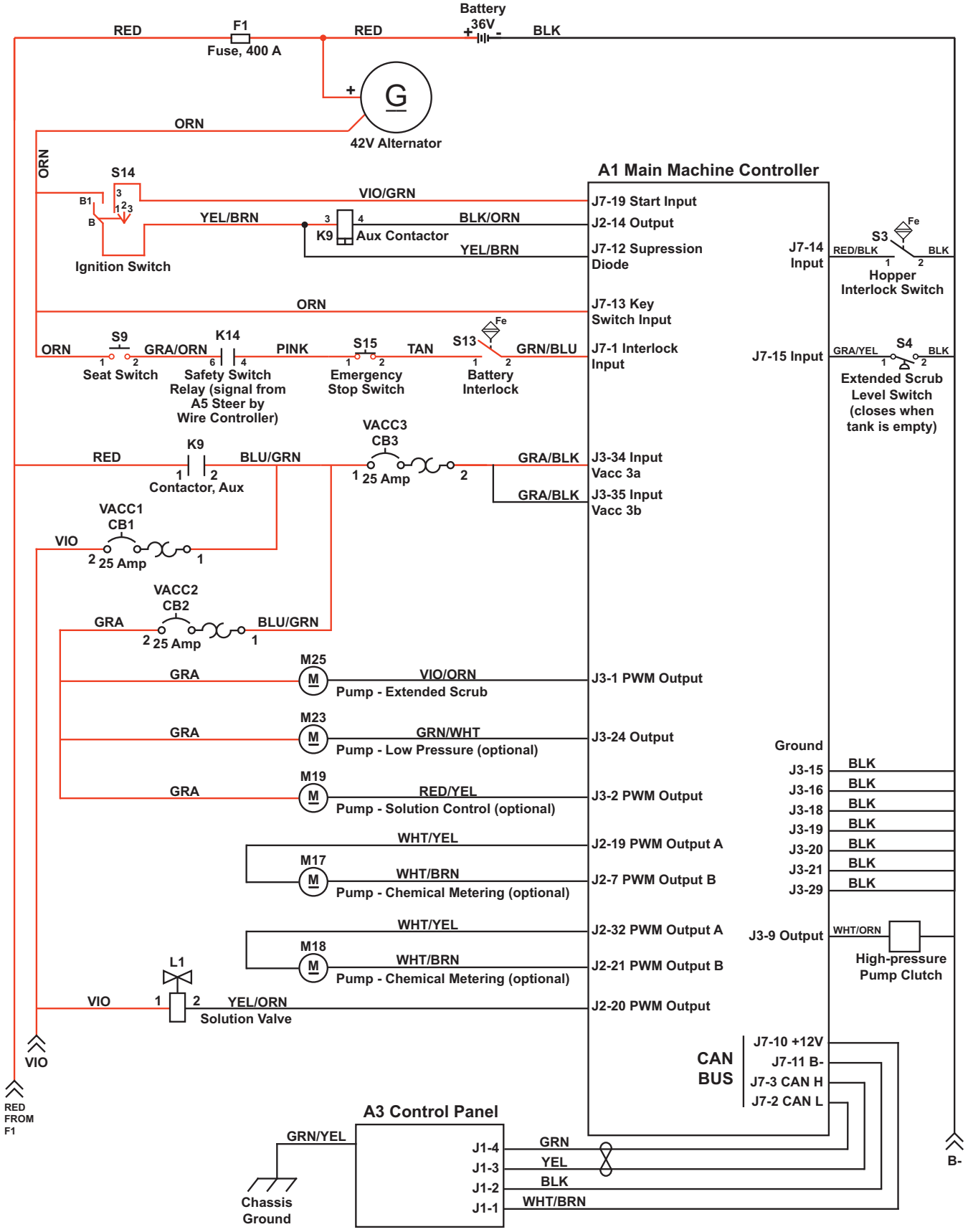
Solution Level Sensor

The solution pressure sensor sends a linear signal to the A1 Main Machine Controller to indicate the solution level in the tank. This signal is proportional to the solution level. An icon on the LCD display indicates the solution level in the tank.

If the solution level has been low longer than 10 seconds, the LCD display will show the solution level low caution icon. The conditions under which the solution level low icon is displayed depend on the state of the extended scrub system as follows:

- With the extended scrub system off:
  - If the clean solution is low, the solution level low icon will be displayed.
  - If the clean solution is not low, the solution level low icon will not be displayed.
- With the extended scrub system on:
  - If the extended scrub solution level in the recovery tank is not low, the solution level low icon will not be displayed.
  - If the extended scrub solution level is low but the clean solution level is not low, the solution level low icon will not be displayed.
  - If both the extended scrub and clean solution levels are low, the solution level low icon will be displayed.

Solution System Wiring Diagram



Circuit Description

The Following Conditions Must be Met for the Solution System to Operate

- The **Hopper Interlock Switch S3** must be closed.
- There must be positive voltage to the **J7-1 Interlock Input**. For this to happen:
  - The **Seat Switch S9** must be closed.
  - The **Safety Relay K14** on the **Steer By Wire Controller A5** must energize the coil to close the **Safety Relay K14** contactor.
  - The **Emergency Stop Switch S15** must be closed.
  - The **Battery Interlock S13** must be closed (battery machines) or jumpered (Diesel and LP machines).
- The **400-amp Fuse F1** must be closed to provide positive voltage from the **Battery** to the load side of **Auxiliary Contactor K9**.
- The **Ignition Switch S14** must be closed to provide positive voltage to the **Auxiliary Contactor K9** coil. The **J2-14 Output** on the **A1 Main Machine Controller** provides ground to the **Auxiliary Contactor K9** coil when the **Ignition Switch S14** provides an input to the **Key Switch Input J7-12**.
- The **Auxiliary Contactor K9** must be closed to provide positive voltage to circuit breakers **VACC1/CB1** and **VACC2/CB2**.
- Circuit breaker **VACC1/CB1** must be closed to provide positive voltage to **Solution Valve L1**.
- Circuit breaker **VACC2/CB2** must closed to provide positive voltage to the **Solution Control Pump M19** (EcoFlex™ machines only). (Note that **VACC2/CB2** must closed to provide positive voltage to the **Extended Scrub Pump M25** and **Low Pressure Pump M23** as well.)
- The **J2-20 PWM Output** provides negative ground to **Solenoid Valve L1,** and the **J3-2 PWM Output** provides negative ground to the **Solution Control Pump M19** under the following conditions:
  - The **A1 Main Machine Controller** must receive a signal from the **A3 Control Panel** via the **CAN BUS** that the operator has pressed the scrub switch.
  - The **A1 Main Machine Controller** must receive a signal from the **A2 Drive Controller** via the **CAN BUS** that the machine is moving forward or (optional) in reverse.

The Following Conditions Must be Met for the Extended Scrub System to Operate

The extended scrub system requires the same conditions to operate as does the solution system, with the following additions:

- The extended scrub function must be installed in the configuration menu.
- The **J3-1 PWM Output** provides the negative ground to the **Extended Scrub Pump M25** under the following conditions:
  - The **A1 Main Machine Controller** must receive a low-solution signal via the **CAN BUS** from the **A3 Control Panel**.
  - The **A1 Main Machine Controller** must receive a signal from the **A3 Control Panel** via the **CAN BUS** that the operator has pressed the extended scrub switch.
  - The **A1 Main Machine Controller** must receive a signal from the **A2 Drive Controller** via the **CAN BUS** that the machine is moving forward or reverse.

– The **Extended Scrub Level** (float) **Switch S4** in the recovery tank must be open to prevent the **J7-15 Input** from going to battery negative. Note the switch opens when there is adequate water in the recovery tank, and closes when the recovery tank is empty.

The Following Conditions Must be Met for the Low Pressure Wash Hose to Operate

Note: *The low pressure wash hose does not require the interlocks to be closed to operate.*

- The low pressure wash function must be installed in the configuration menu.
- The **400-amp Fuse F1** must be closed to provide positive voltage from the **Battery** to the load side of **Auxiliary Contactor K9**.
- The **Ignition Switch S14** must be closed to provide positive voltage to the **Auxiliary Contactor K9** coil. The **J2-14 Output** on the **A1 Main Machine Controller** provides ground to the **Auxiliary Contactor K9** coil when the **Ignition Switch S14** provides voltage to the **Key Switch Input J7-13**.
- Circuit breaker **VACC2/CB2** must closed to provide positive voltage to the **Low Pressure Pump M23**.
- The **J3-24 Output** must provide negative ground to the **Low Pressure Pump M23**. This output will be active whenever the key switch is on.
- The internal pressure switch in the **Low Pressure Pump M23** must be closed for the pump to run.

Note: *The internal pressure switch in the low pressure pump is set to switch the pump on at 25 psi ± 5 psi (when the hose nozzle is opened), and shut pump off at 45 psi (when the hose nozzle is closed).*

The Following Conditions Must be Met for the EcoFlex™ System to Operate

The **J2-19**, **J2-7**, **J2-32** and **J2-21 PWM Outputs** provide power to the **Chemical Metering Pumps M17** and **M18** respectively under the following conditions:

- The detergent system and EcoFlex™ system must both be installed in the configuration menu.
- The **A1 Main Machine Controller** must receive a signal from the **A3 Control Panel** via the **CAN BUS** that the operator has pressed the scrub and EcoFlex™ switches.
- The **A1 Main Machine Controller** must receive a signal from the **A2 Drive Controller** via the **CAN BUS** that the machine is moving forward or reverse.

The Following Conditions Must be Met for the High-pressure Spray System to Operate

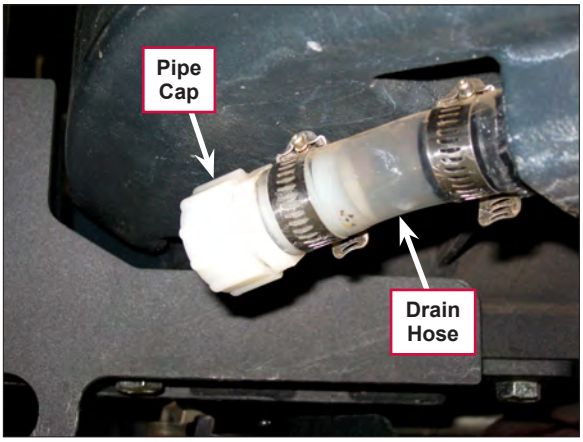
- The high pressure wash system must be installed in the configuration menu.
- The **J3-8 Output** provides positive voltage to the **High Pressure Pump Clutch** under the following conditions:
  - The **A1 Main Machine Controller** must receive a signal from the **A3 Control Panel** via the **CAN BUS** that the scrub and detergent systems are enabled.
  - The **A1 Main Machine Controller** must receive a signal from the **A2 Drive Controller** via the **CAN BUS** that the machine is in Neutral and NOT moving forward or reverse. (The feature is disables when the machine is moving.)
- The **High Pressure Pump Clutch** must be connected to battery negative.

Component Locations

Solution Tank

Drain Hose

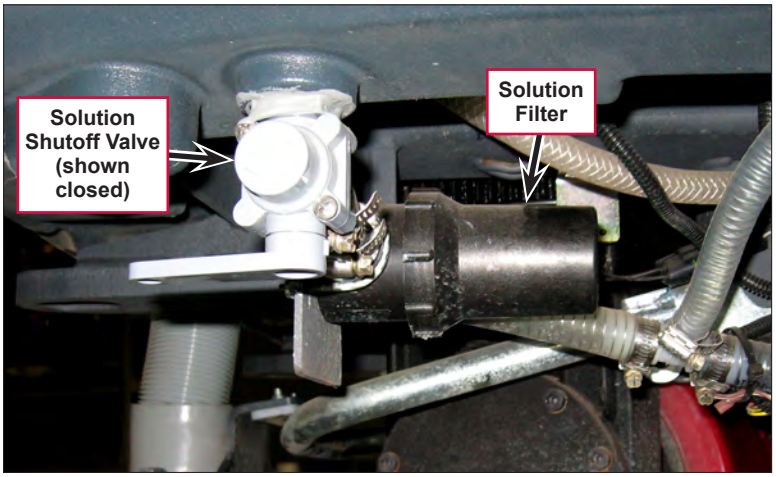
The **Drain Hose** underneath the rear right-hand side of the solution tank allows you to drain the solution tank. To drain the tank, remove the **Pipe Cap**.



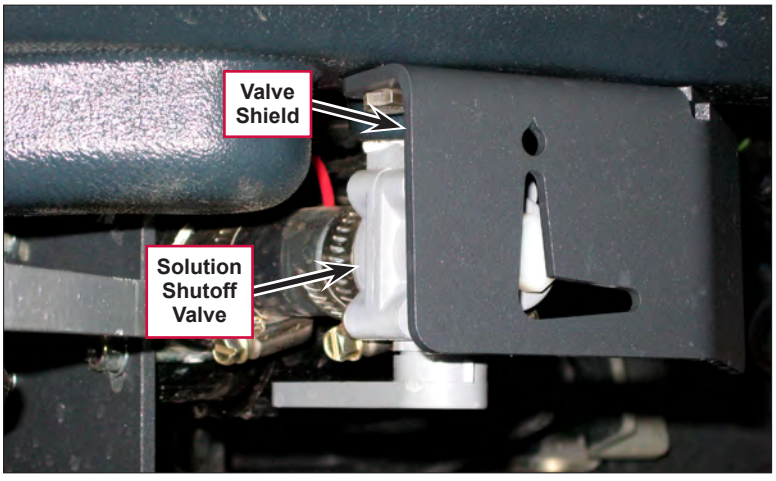
Solution Filter and Solution Shutoff Valve

The **Solution Filter** and **Solution Shutoff Valve** are mounted underneath the rear right-hand side of the solution tank.

- The **Solution Filter** prevents any dirt or particulates that may be in the solution tank from entering the solution solenoid valve and solution system.
- The **Solution Shutoff Valve** allows you shut off the solution flow to the machine for solution system maintenance.

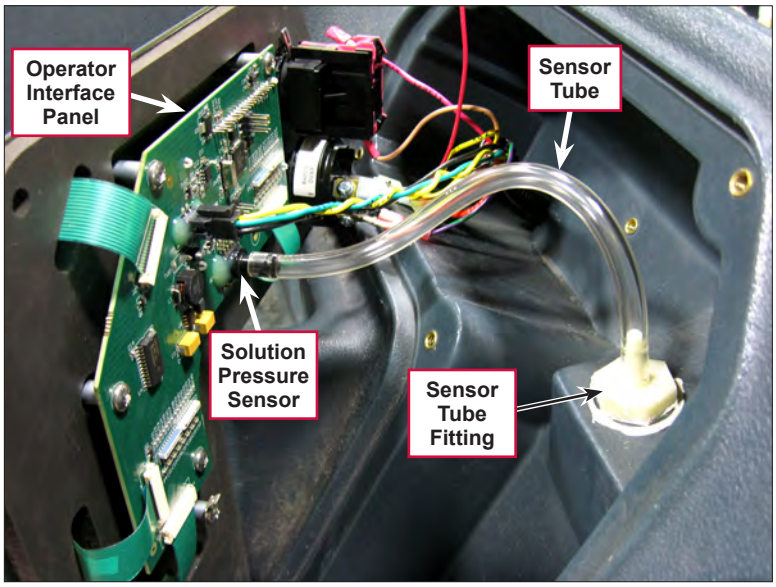


Note: *There is a **Valve Shield** mounted onto the solution tank that is not shown in the above photo. The **Valve Shield** is designed to prevent damage to the **Solution Shutoff Valve**.*



Solution Pressure Sensor

The **Solution Pressure Sensor** on the back of the **Operator Interface Panel** uses the air pressure in the **Sensor Tube** to determine the solution level in the tank. The **Sensor Tube** is connected via the **Sensor Tube Fitting** to a hollow vertical tube inside the solution tank. This vertical tube is open at the bottom and is filled with air. The solution in the tank will exert pressure on the air in the tube proportional to the level of solution in the tank. The **Solution Pressure Sensor** monitors the air pressure in the **Sensor Tube** and converts this pressure value to a solution level as shown on the LCD display on the **Operator Interface Panel**.

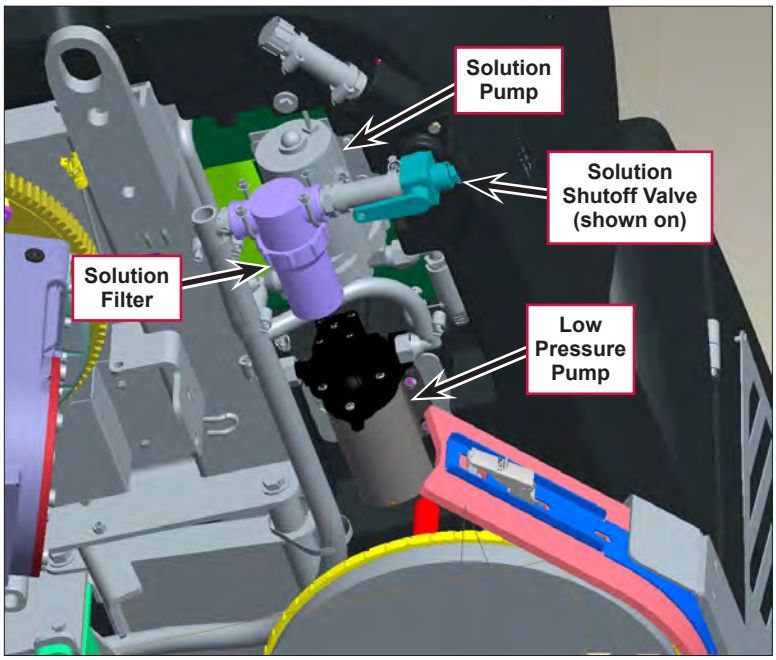


Solution Pump (EcoFlex™ Models Only)

The **Solution Pump** is mounted underneath the rear right-hand side of the solution tank and pumps the solution to the solution solenoid valve.

Low Pressure (Wash Hose) Pump

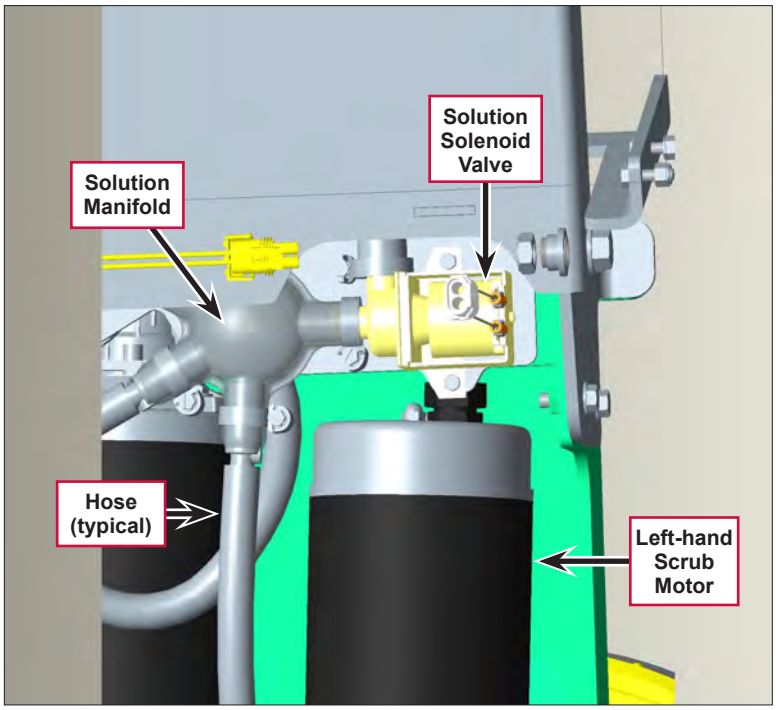
The optional **Low Pressure** (wash hose) **Pump** is mounted next to the **Solution Pump** underneath the rear right-hand side of the solution tank. The **Low Pressure Pump** pumps solution to the optional wash hose behind the Operator seat.



Solution Solenoid Valve

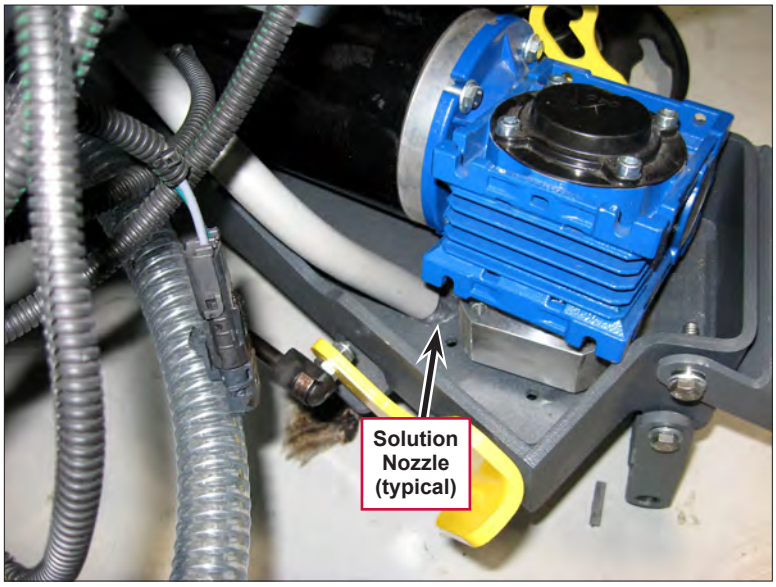
The **Solution Solenoid Valve** is located on the top center of the scrub deck and supplies the solution to the **Solution Manifold**. The **Solution Manifold** connects to the three **Hoses** going to the three scrub brushes. Note that the adjacent drawing is a top view looking down onto the scrub deck.

Note that the **Solution Solenoid Valve** is designed to be easy to remove and install. It is possible for dirt or debris to interfere with the **Solution Solenoid Valve** seat and prevent the seat from sealing. This can prevent the **Solution Solenoid Valve** from shutting off the solution flow completely and requires that the **Solution Solenoid Valve** be cleaned or replaced.



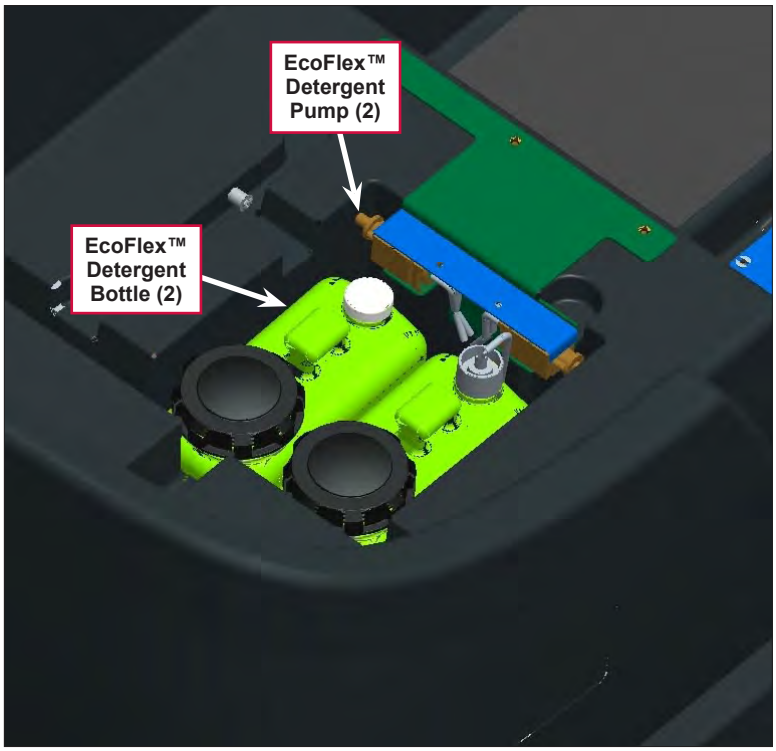
Solution Nozzles

The **Solution Nozzles** are part of the deck weldment and direct the solution onto the brushes. (The right-hand scrub motor has been loosened and moved slightly in order to show the **Solution Nozzle**.)



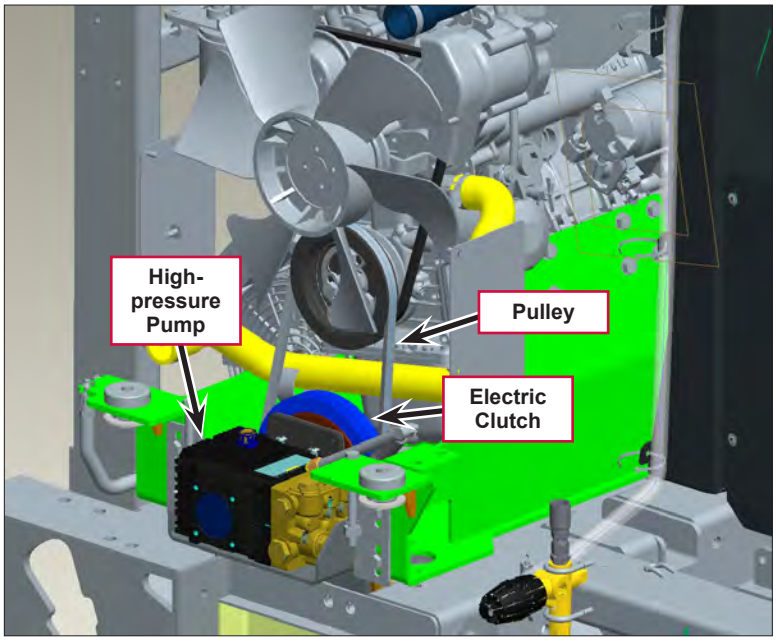
EcoFlex™ Detergent Bottles and Pumps

The **EcoFlex™ Detergent Bottles** are located underneath the Operator seat and supply detergent to the two **EcoFlex™ Detergent Pumps**. The two **EcoFlex™ Detergent Pumps** run simultaneously and pump detergent through separate lines that merge into one main detergent supply line. The detergent supply line is plumbed into the solution supply upstream of the solution solenoid valve.



High-pressure Spray System Pump

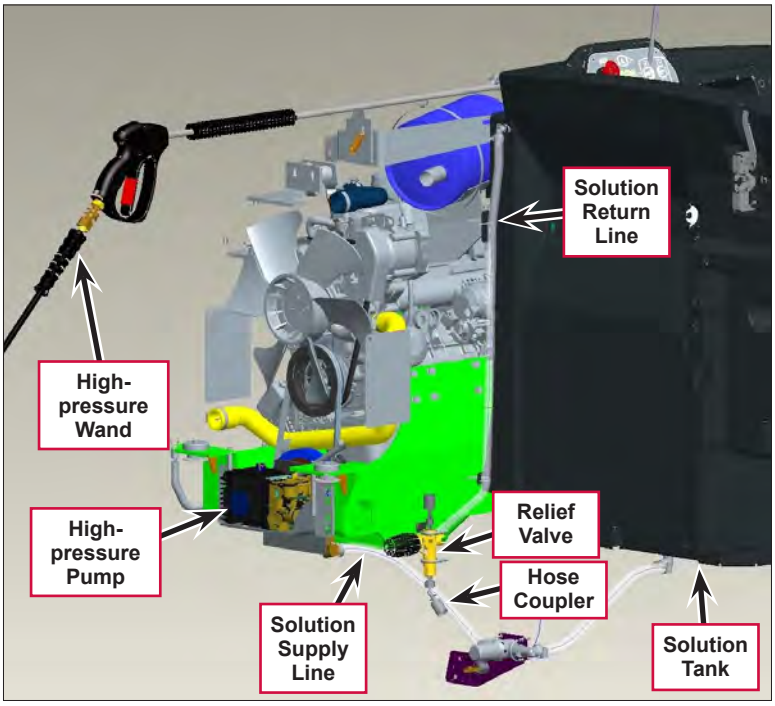
The **High-pressure Pump** is driven by an **Electric Clutch** run by a **Pulley** off of the engine. The **Electric Clutch** is engaged and drives the **High-pressure Pump** when the Operator presses the high-pressure wand switch on the control panel.



The **Solution Supply Line** supplies solution from the **Solution Tank** to the **High-pressure Pump**. The **High-pressure Pump** pumps the solution to the **Relief Valve** which functions as follows:

- If the trigger valve on the **High-pressure Wand** is open, the solution flows through the **Hose Coupler** and to the attached **High-pressure Wand**.
- If the trigger valve on the **High-pressure Wand** is closed, the **Relief Valve** directs the solution into the **Solution Return Line** and back into the **Solution Tank**.

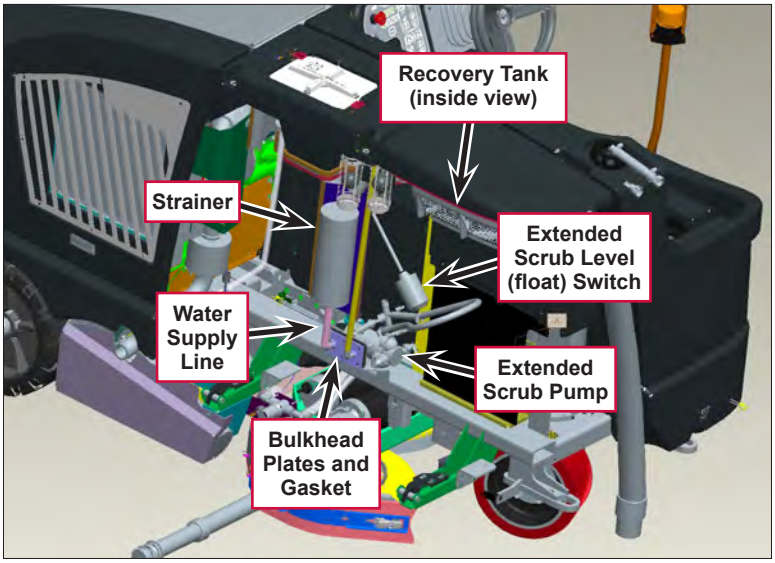
Note that the **Relief Valve** is pre-set at the factory and is not adjustable.



Extended Scrub System

When the **Extended Scrub Level** (float) **Switch** inside the **Recovery Tank** closes to indicate adequate water level, the **Extended Scrub Pump** switches on to pump water to the scrub brushes. The water passes through the **Strainer** inside the **Recovery Tank**, then through the **Water Supply Line** in the **Bulkhead Plates and Gasket** to the inlet side of the **Extended Scrub Pump**. Note that the second piece of conduit in the **Bulkhead Plates and Gasket** is for the **Extended Scrub Level Switch** wires.

The **Extended Scrub Pump** is mounted to a bracket outside of the **Recovery Tank**. The water from the **Extended Scrub Pump** is plumbed into the solution line upstream of the solution solenoid valve.



Maintenance and Adjustments

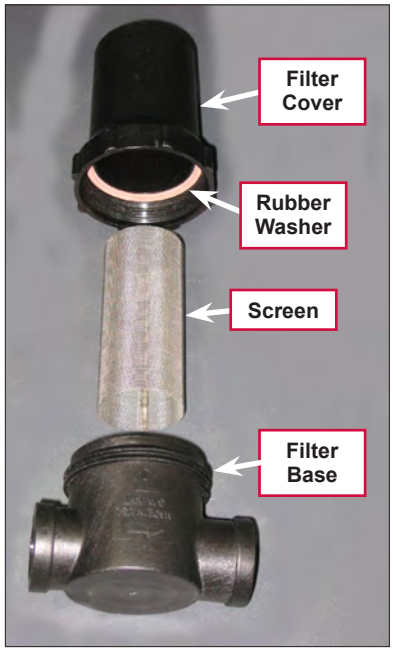
Warning! ***Before performing any machine maintenance or adjustments, make sure the key switch is off, the key is removed from the machine and the parking brake is engaged.***

To Clean the Solution Filter Screen

1. Close the solution shutoff valve.

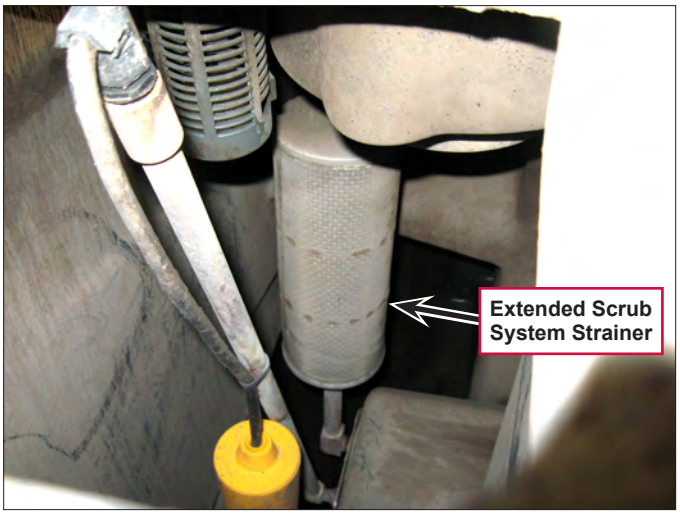
Note: *Place a suitable container underneath the filter to catch any solution that may leak from the hoses.*

2. Unscrew the **Filter Cover** and remove the **Filter Cover** and **Screen** from the **Filter Base**.
3. Clean any accumulated dirt or debris from the **Screen**.
4. Reinstall the **Screen** into the **Filter Base**.
5. Make sure the **Rubber Washer** is installed correctly in the **Filter Cover**, then reinstall and hand-tighten the **Filter Cover**.



To Clean the Extended Scrub System Strainer

1. Open the recovery tank cover and remove the debris basket.
2. Rinse any accumulated material off of the **Extended Scrub System Strainer** using normal water hose pressure.
3. Reinstall the debris basket and close the recovery tank cover.

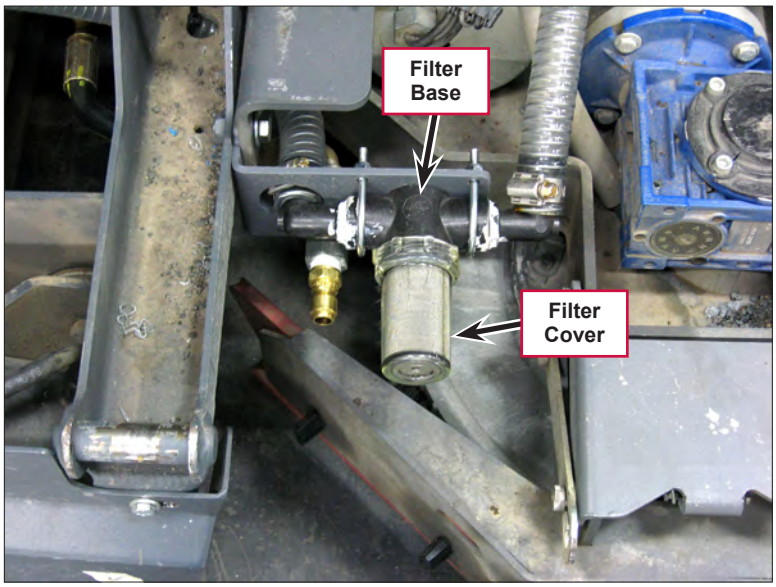


To Clean the High Pressure Solution Filter

1. Drain and remove the recovery tank.

Note: *Place a suitable container underneath the filter to catch any solution that may leak from the hoses.*

2. Unscrew the **Filter Cover** and remove the **Filter Cover** and screen from the **Filter Base**.
3. Clean any accumulated dirt or debris from the screen.
4. Reinstall the screen into the **Filter Base**.
5. Make sure the rubber washer is installed correctly in the **Filter Cover**, then reinstall and hand-tighten the **Filter Cover**.



To Adjust the Belt Tension on the High Pressure Pump

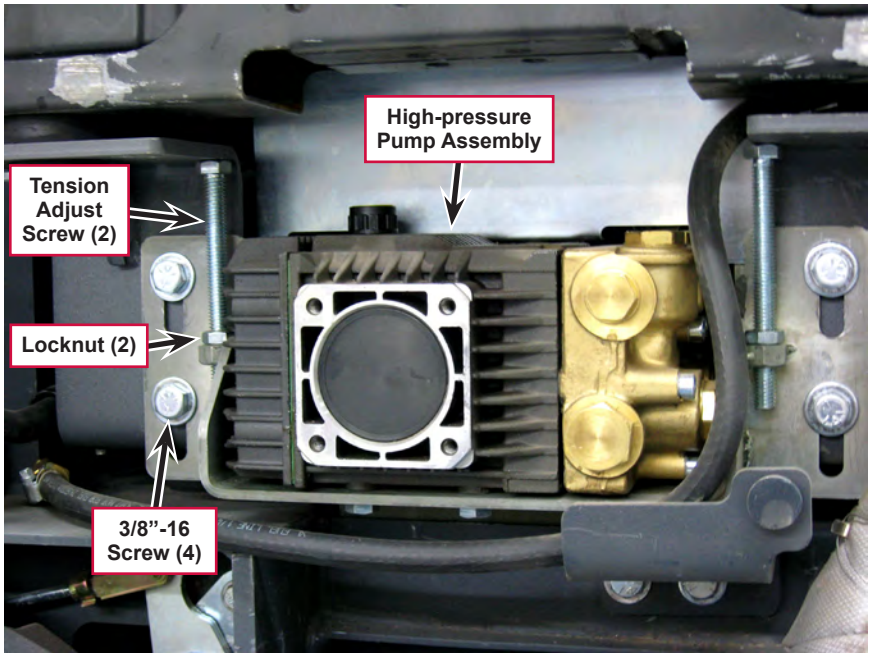
1. Drain and remove the recovery tank.

2. Loosen the four **3/8”-16 Screws** holding the **High-pressure Pump Assembly** to the machine frame.

3. Loosen the **Locknuts** on the two **Tension Adjust Screws**.

4. Adjust the **Tension Adjust Screws** to move the **High-pressure Pump Assembly** up or down as necessary to obtain the correct drive belt tension as follows:

   - **LPG Machines** - For a new belt, a deflection of 0.12” when a force of 2.6 to 2.8 lbs is applied and for a used belt a deflection of 0.12” when a force of 2.2 to 2.4 lbs is applied..
   - **Diesel Machines** - For a new belt, a deflection of 0.13” when a force of 2.4 to 2.5 lbs is applied and for a used belt a deflection of 0.13” when a force of 2.1 to 2.2 lbs is applied.



5. When the belt tension is correct:

   a. Hold the **Tension Adjust Screws** in position to keep them from turning, then tighten the **Locknuts**.

   b. Tighten the four **3/8”-16 Screws**.

Troubleshooting

Note: *You can use the Service Mode to toggle the various system components on and off to check for function. Refer to the* ***Control System/Service Mode*** *section for information on how to enter and use the Service Mode.*

Problem	Cause	Correction
The solution system does not operate.	An interlock is not closed.	Before you start troubleshooting a specific system, check to make sure: • The emergency stop switch (**S15**) on the Operator control panel is disengaged (rotate clockwise). • The safety relay from the steering system (**K14**) is closed. • The seat switch (**S9**) is closed. • The battery interlock proximity sensor (**S13**) is closed. • The A1 Main Machine Controller is receiving the appropriate signal from the A3 Control Panel via the CAN BUS.
Inadequate solution flow to the brushes in the scrub mode	Inadequate solution level in tank	Check the solution level.
	The solution filter screen is plugged.	Clean the solution filter screen.
	The solution shutoff valve is plugged or inoperative.	Clean or replace the solution shutoff valve.
	The solution solenoid valve is plugged or not functioning.	Check the solution solenoid coil resistance. It should measure 72 ohms ± 10%. If the coil resistance is not within spec replace the solution solenoid valve.
	The solution manifold/solution hoses/solution nozzles are plugged.	Check and clean the manifold/hoses/solution nozzles as necessary.
	The solution control pump (**M19**) is not operating (EcoFlex™ machines only).	Check for voltage at the pump. • If there is voltage at the pump, replace the pump. • If there is no voltage at the pump: 1. Check the wiring and circuit breakers upstream of the pump. 2. Check the **J3-2** output from A1 Main Machine Controller.

Problem	Cause	Correction
Inadequate solution flow to the brushes in the extended scrub mode	The extended scrub function is not installed in the configuration menu.	Install the extended scrub function in the configuration menu.
	The stainer in the recovery tank is dirty or plugged.	Remove and clean the strainer.
	The extended scrub level (float) switch (**S4**) is not providing a ground to **J7-15 Input** on A1 Main Machine Controller.	The switch should be closed when in the lowermost position (tank empty), and open when in the uppermost position (tank full). If the continuity through the switch in its upper and lower positions is not correct: 1. Check the wiring and repair as necessary. 2. If the wiring is OK, replace the switch.
	The extended scrub pump (**M25**) is not operating correctly.	Check for voltage at the pump. • If there is voltage at the pump, replace the pump. • If there is no voltage at the pump: 1. Check the wiring and circuit breakers upstream of the pump. 2. Check the **J3-1** output from A1 Main Machine Controller.
No detergent flow to the solution system	The detergent and EcoFlex™ functions are not installed in the configuration menu.	Install both the detergent and EcoFlex™ functions in the configuration menu.
	The detergent supply lines are clogged.	Check the detergent lines and clean/replace as necessary.
	One or both of the detergent pumps are not operating correctly.	Check for voltage at the pumps. • If there is voltage at a pump, replace the pump. • If there is no voltage at a pump: 1. Check the wiring from **J2-19** and **J2-7**, and **J2-32** and **J2-21** to the pumps. 2. Check the **J2-19**, **J2-7**, **J2-32** and **J2-21** outputs from A1 Main Machine Controller.
The hot water system is not operating.	The solution is not circulating through the heat exchanger.	Check the solution hoses to and from the heat exchanger and repair/replace as necessary.

Problem	Cause	Correction
The high-pressure spray system is not operating.	The high-pressure wand switch on the control panel has not been pressed.	Press the high-pressure wand switch to engage the high-pressure solution pump.
	The high pressure wash function is not installed in the configuration menu.	Install the high pressure wash function in the configuration menu.
	The solution filter screen is plugged.	Clean the solution filter screen.
	The high-pressure pump clutch is not engaging.	Check that the belt on the engine pulley is driving the clutch pulley. Adjust the belt tension or replace the belt as necessary.
		Check the connection from the clutch to battery ground and repair as necessary.
		Check the output from **J3-9** on A1 Main Machine Controller. If there is voltage from **J3-9** to the clutch, replace the clutch.
	The relief valve is not operating.	Replace the relief valve.
The low-pressure wash hose is not operating.	The low pressure wash function is not installed in the configuration menu.	Install the low pressure wash function in the configuration menu.
	The low-pressure pump (**M23**) is not operating.	Check for voltage at the pump. • If there is voltage at the pump, replace the pump. • If there is no voltage at the pump: 1. Check the wiring and circuit breakers upstream of the pump. 2. Check the **J3-24** output from A1 Main Machine Controller.

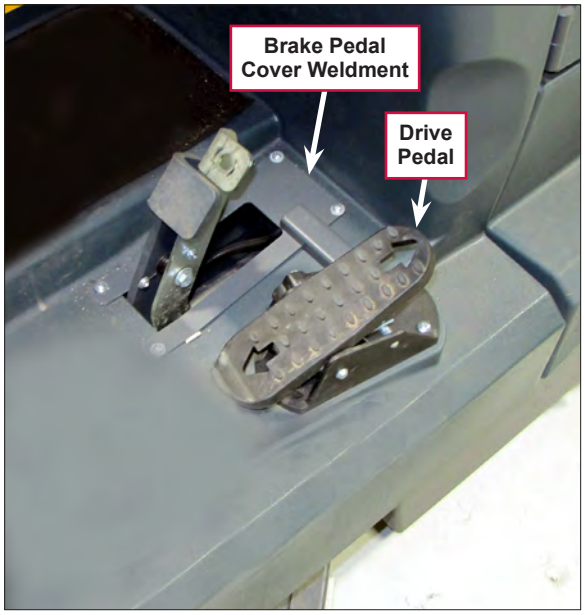
Removal and Installation

Warning! ***Before removing or reinstalling any machine components, make sure the key switch is off, the key is removed from the machine and the parking brake is engaged.***

To Remove and Reinstall the Solution Tank

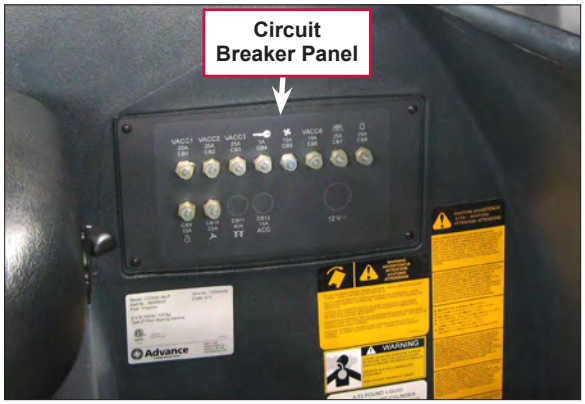
Caution: ***The solution tank is relatively heavy. It's recommended that the solution tank be removed by two or more persons, using the appropriate equipment, to prevent possible personal injury or damage to the solution tank.***

1. Disconnect the battery/batteries.
2. Drain and remove the recovery tank.
3. Drain the solution tank.
4. Disconnect the solution hoses from the solution tank.
5. Disconnect the electrical connector from the **Drive Pedal**.
6. Remove the **Brake Pedal Cover Weldment**.

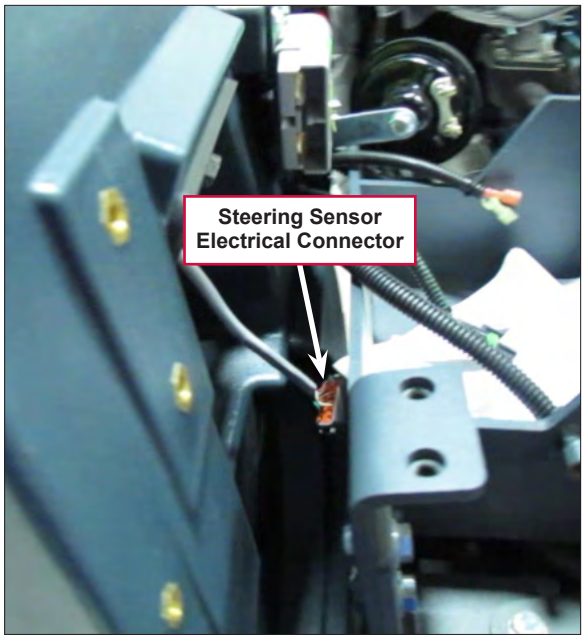


7. Remove the **Circuit Breaker Panel** and disconnect the circuit breaker connectors.

Note: *Label the circuit breaker connectors as you remove them to make sure they are reconnected correctly.*

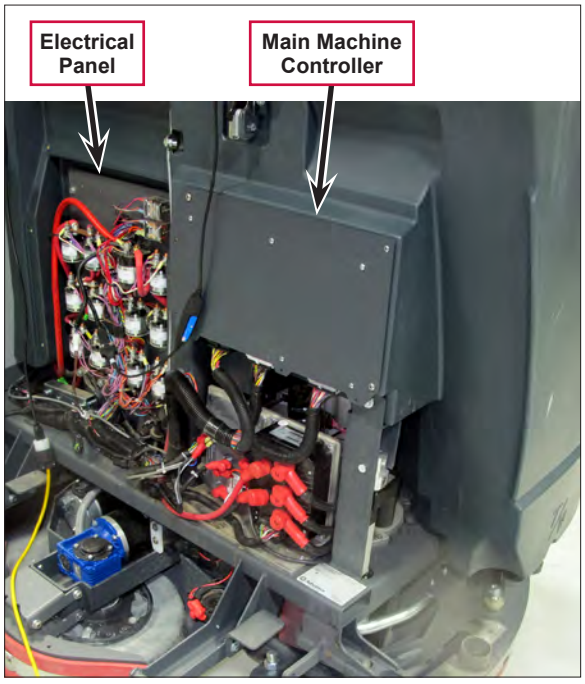


8. Disconnect the **Steering Sensor Electrical Connector**.



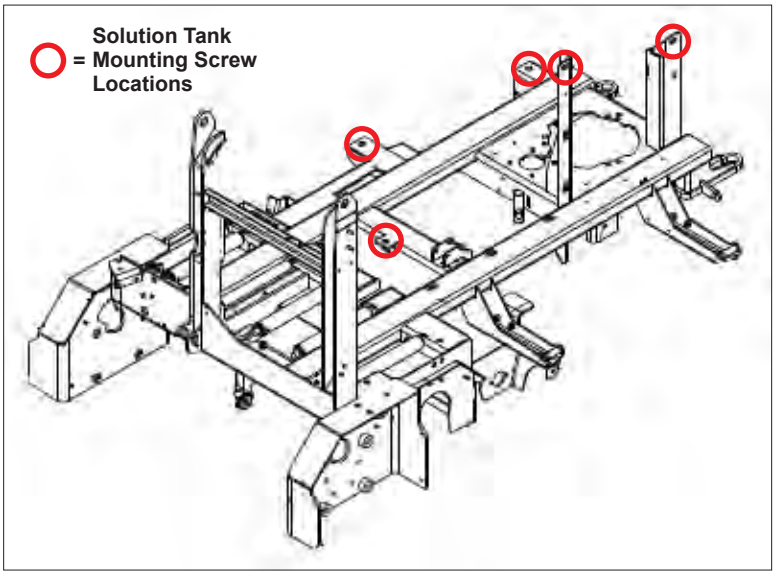
9. Disconnect the additional wiring running from the solution tank to the engine (ground, starter, engine interface, etc.).

10. Remove the **Electrical Panel**.
11. Remove the **Main Machine Controller**.
12. Disconnect any additional solution lines or electrical connectors from the solution tank that may be present if your machine is equipped with an extended scrub system, high-pressure spray system or wash hose kit.

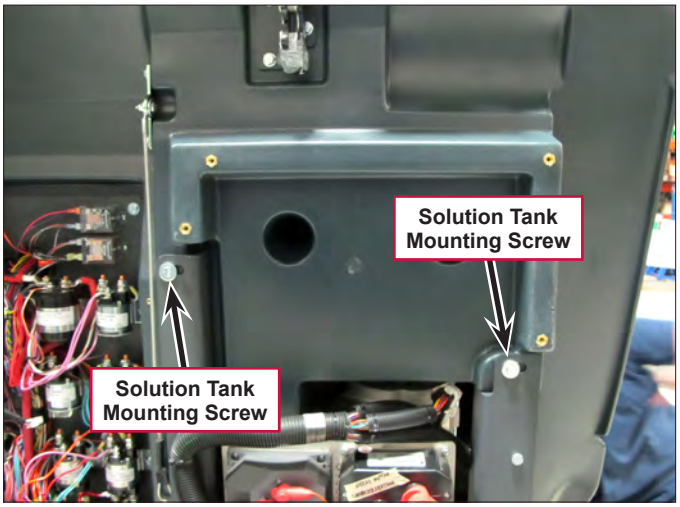


13. Remove the five mounting screws holding the solution tank to the frame. The mounting screw locations are shown below.

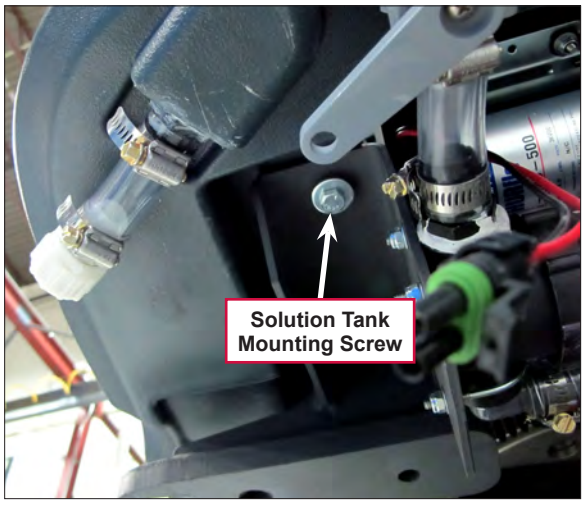
The three bottom mounting screws are located underneath the machine - two on the right side and one in the center of the frame. The two top mounting screws are located on the vertical supports on the left side of the machine where the main machine controller is mounted.



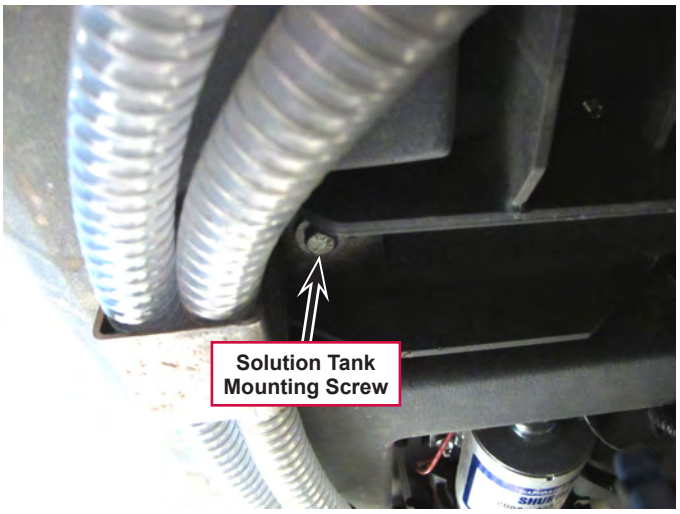
The two top **Solution Tank Mounting Screws** are located on the vertical supports on the left side of the machine.



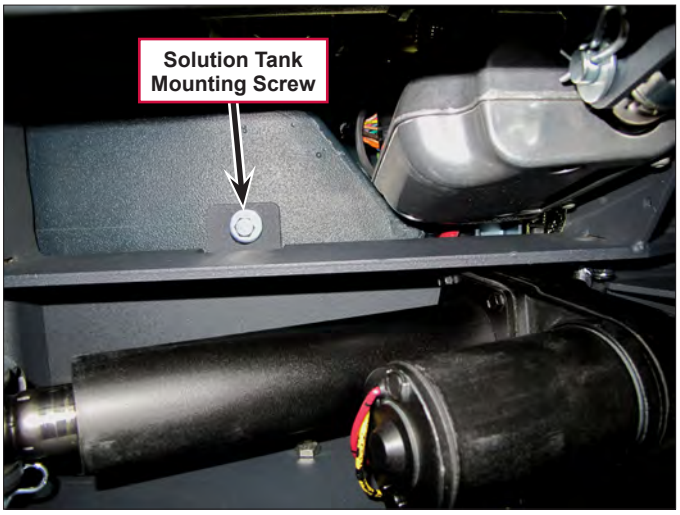
The bottom rear **Solution Tank Mounting Screw** is located underneath the machine on the right side by the solution shutoff valve and drain hose.



The bottom center **Solution Tank Mounting Screw** is located underneath the machine by the right-hand side squeegee assembly.



The bottom front **Solution Tank Mounting Screw** is located underneath the machine by the main broom actuator and scrub deck actuator.



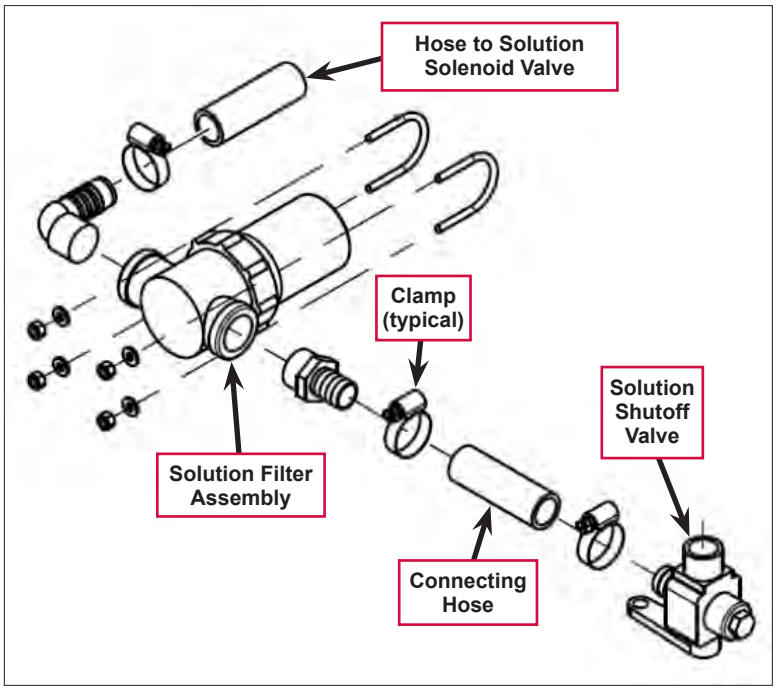
14. Remove the solution tank from the machine.
15. Reinstall the solution tank by following the above steps in reverse order.

To Remove and Reinstall the Solution Shutoff Valve

1. Drain the solution tank.
2. Remove the valve shield.
3. Remove the nuts, washers and U-bolts holding the **Solution Filter Assembly** to the mounting plate.

Note: *Place a suitable container underneath the shutoff valve to catch any solution that may leak from the hoses or filter.*

4. Loosen the clamp holding the **Connecting Hose** to the **Solution Shutoff Valve**, then disconnect the **Connecting Hose** and attached **Solution Filter Assembly** from the **Solution Shutoff Valve**.
5. Carefully unscrew the **Solution Shutoff Valve** from the solution tank.
6. Reinstall the **Solution Shutoff Valve** by following the above steps in reverse order.



Service Note: *Apply Loctite® "No More Leaks" White Threaded Plastic Pipe Sealant to the* ***Solution Shutoff Valve*** *threads before installing it into the solution tank. Make sure the* ***Solution Shutoff Valve*** *is oriented correctly on the tank so the barbed fitting on the* ***Solution Shutoff Valve*** *aligns with* ***Connecting Hose*** *on the* ***Solution Filter Assembly****.*

To Remove and Reinstall the Solution Filter Assembly

1. Close the **Solution Shutoff Valve**.
2. Remove the nuts, washers and U-bolts holding the **Solution Filter Assembly** to the mounting plate.

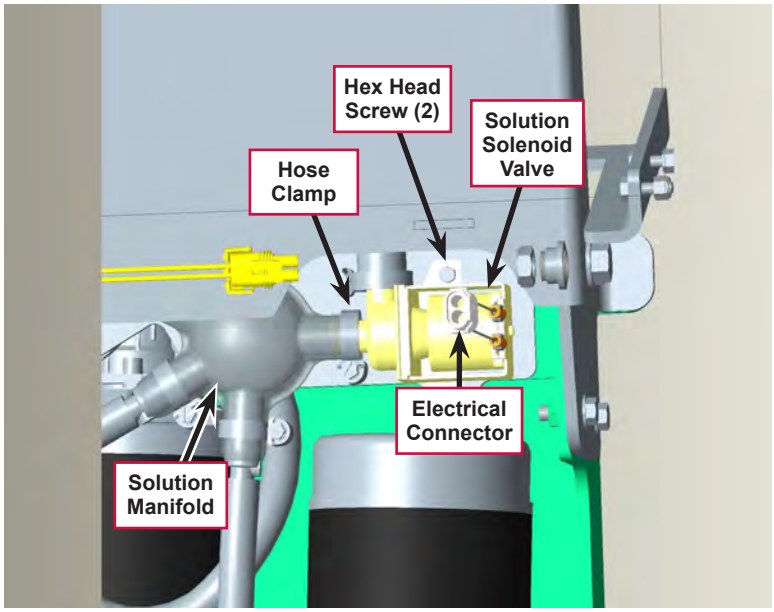
Note: *Place a suitable container underneath the filter to catch any solution that may leak from the filter or hoses.*

3. Loosen the clamp holding the **Connecting Hose** to the **Solution Filter Assembly**, then remove the **Connecting Hose** from the **Solution Filter Assembly**.
4. Loosen the clamp on the **Hose** that runs from the **Solution Filter Assembly** to the **Solution Solenoid Valve** and remove the **Hose** from the **Solution Filter Assembly**.
5. Remove the **Solution Filter Assembly** from the machine.
6. Reinstall the **Solution Filter Assembly** by following the above steps in reverse order.

To Remove and Reinstall the Solution Solenoid Valve

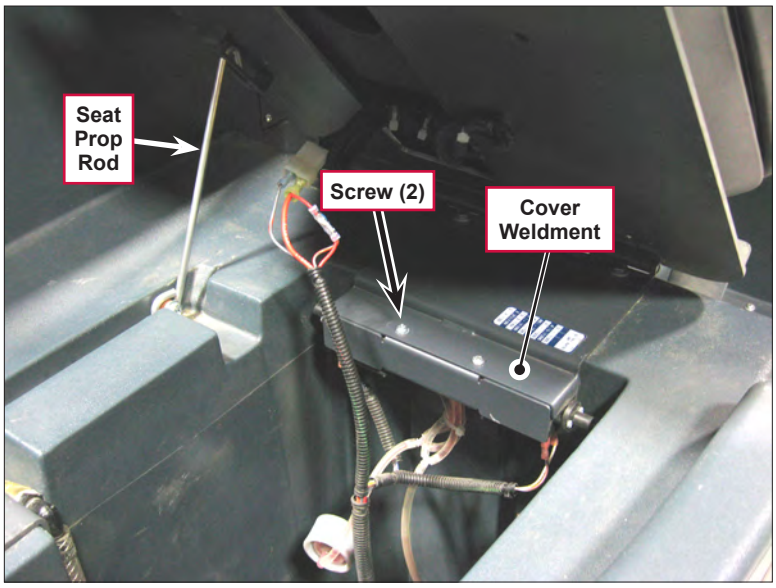
Service Note: *You can remove and the reinstall the solution solenoid valve with the scrub deck either in or out of the machine.*

1. Empty and remove the recovery tank from the machine.
2. Remove the scrub deck from the machine (if desired). (Refer to the ***Scrub System*** section.)
3. Disconnect the **Electrical Connector** on the **Solution Solenoid Valve** from the adjacent wiring harness. Note that you may need to cut the wire tie holding the **Solution Solenoid Valve** wires to the **Solution Manifold**.
4. Loosen the **Hose Clamp** holding the **Solution Solenoid Valve** to the **Solution Manifold**.
5. Remove the two **Hex Head Screws** holding the **Solution Solenoid Valve** to the deck assembly and remove the **Solution Solenoid Valve** from the machine.
6. Reinstall the **Solution Solenoid Valve** following the above steps in reverse order.

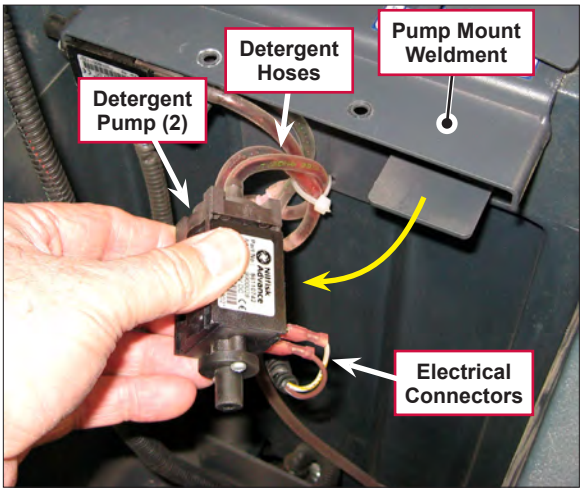


To Remove and Reinstall a Detergent Pump (EcoFlex™ Models Only)

1. Lift up the Operator seat and engage the **Seat Prop Rod**.
2. Remove the detergent bottles.
3. Remove the two **Screws** holding the **Cover Weldment** and remove the **Cover Weldment**.



4. Carefully slide the **Detergent Pump** out of the **Pump Mount Weldment**.
5. Disconnect the **Detergent Hoses** and **Electrical Connectors**, then remove the **Detergent Pump** from the machine.
6. Reinstall the **Detergent Pump** by following the above steps in reverse order.



Specifications

Component	Specifications
Solution Solenoid Valve	36V, Coil Resistance - 72 ohms ± 10%
EcoFlex™ Detergent Pump	Type - diaphragm dosing pump with stroke adjustment
	Voltage - 12 VDC
	Flow Calibration - 87 ml/min ± 3 ml/min
	Water Lift - 3.5 in
Solution Control Pump (EcoFlex™ models only) Extended Scrub Pump	Type - diaphragm, self-priming, internal check valve
	Voltage - 36 VDC, permanent magnet
	Current - 3.9 Amps max.
	Flow Rate - 3.3 GPM @ 2.75 Amps with 20 psi inlet pressure

<table>
<tr><th>Component</th><th colspan="3">Specifications</th></tr>
<tr><td rowspan="9">Low-pressure (Wash Hose) Pump</td><td colspan="3">Type - diaphragm, self-priming, internal check valve</td></tr>
<tr><td colspan="3">Voltage - 36 VDC, permanent magnet</td></tr>
<tr><td colspan="3">Internal pressure switch:
• Set to switch pump on at 25 ± 5 psi
• Set to shut pump off at 45 psi</td></tr>
<tr><td colspan="3">Performance Specifications (average)</td></tr>
<tr><td>Pressure (psi)</td><td>GPM</td><td>Amps</td></tr>
<tr><td>10</td><td>3.16</td><td>2.1</td></tr>
<tr><td>20</td><td>3.00</td><td>2.6</td></tr>
<tr><td>30</td><td>2.76</td><td>2.9</td></tr>
<tr><td>40</td><td>2.62</td><td>3.2</td></tr>
<tr><td>50</td><td>2.26</td><td>3.5</td></tr>
<tr><td rowspan="6">High Pressure Pump</td><td colspan="3">Type - Axial piston</td></tr>
<tr><td colspan="3">Max. Pump Speed - 1750 RPM</td></tr>
<tr><td colspan="3">Max. Flow Rate - 2.11 gpm [8 l/min]</td></tr>
<tr><td colspan="3">Max Outlet Pressure - 2,200 psi [150 bar]</td></tr>
<tr><td colspan="3">Max Inlet Pressure - 116 psi [8 bar]</td></tr>
<tr><td colspan="3">Oil Type - SAE 30, 10 oz. capacity</td></tr>
<tr><td colspan="3">Shaft Rotation - counterclockwise, horizontal mounting only</td></tr>
</table>

Special Tools

Loctite® “No More Leaks” White Threaded Plastic Pipe Sealant (used on solution shutoff valve threads)	

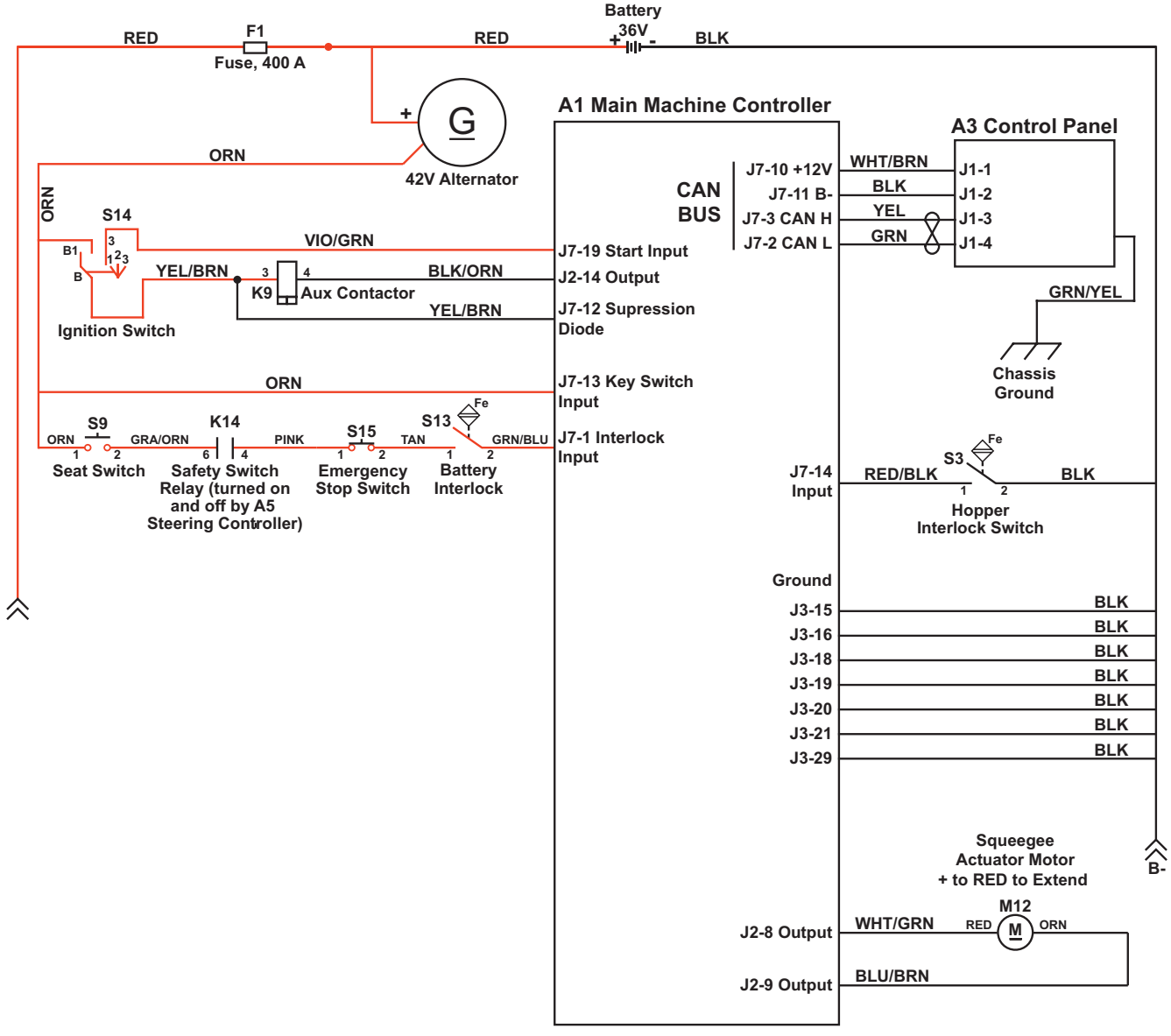
Squeegee System

Functional Description

Overview

The squeegee assembly is mounted at the bottom rear of the machine and picks up the water from the floor. Two squeegee blades (front and rear) pick up the water and direct it into the squeegee support assembly. A vacuum hose attached to the support assembly lifts the water from the squeegee and directs it to the recovery tank. The squeegee lift actuator raises and lowers the squeegee as appropriate for the operation being performed. The squeegee mounting system is designed to allow the squeegee blades enough side-to-side movement to conform to the floor surface and swing sideways when turning.

Squeegee System Wiring Diagram



Circuit Description

The following conditions must be met for the squeegee system to operate:

- The **Hopper Interlock Switch S3** must be closed.
- There must be positive voltage to the **J7-1 Interlock Input**. For this to happen:
  - The **Seat Switch S9** must be closed.
  - The **Safety Relay K14** on the **Steer By Wire Controller A5** must energize the coil to close the **Safety Relay K14** contactor.
  - The **Emergency Stop Switch S15** must be closed.
  - The **Battery Interlock S13** must be closed.
- The **A1 Main Machine Controller** must receive a signal from the **A3 Control Panel** via the CAN BUS that the operator has pressed the scrub switch.
- The **J2-8** and **J2-9 Outputs** from the **A1 Main Machine Controller** provide voltage to the **Squeegee Actuator Motor M12**. The output polarity determines whether the **Squeegee Actuator Motor** lowers or raises the squeegee.

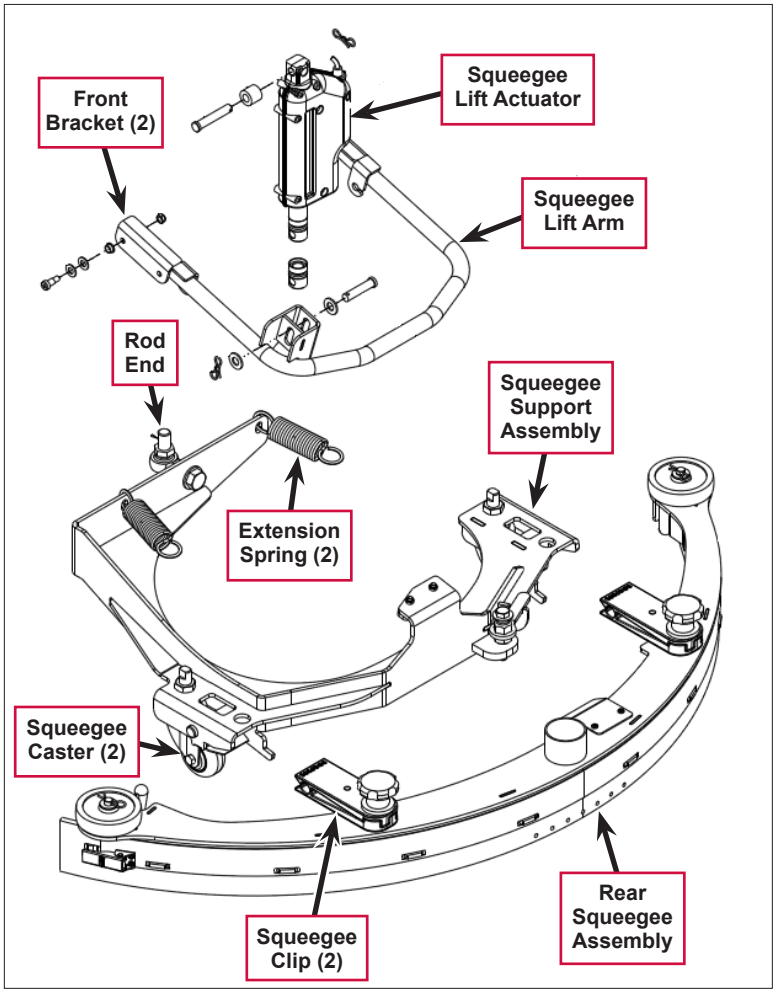
Component Locations

The **Rear Squeegee Assembly** is attached to the **Squeegee Support Assembly** with two split **Squeegee Clips** that clamp onto horizontal pins in the **Squeegee Support Assembly**.

The front of the **Squeegee Support Assembly** is attached to the machine frame by a pivoting **Rod End**. This allows the rear of the **Squeegee Support Assembly** and attached squeegee to tilt up and down, and pivot side-to-side to conform to the floor surface. The two **Squeegee Casters** support the **Squeegee Support Assembly** on the floor.

The rear of the **Squeegee Support Assembly** rests on and is supported by the **Squeegee Lift Arm**. The pivoting **Front Brackets** on the **Squeegee Lift Arm** are attached to the machine frame. The **Squeegee Lift Actuator** raises and lowers the rear of the **Squeegee Lift Arm**, which pivots up and down to raise and lower the **Squeegee Support Assembly** and the attached **Rear Squeegee Assembly**.

The **Squeegee Support Assembly** and **Rear Squeegee Assembly** swing left-to-right to allow the **Rear Squeegee Assembly** to pick up water on the inside of the corner when machine is turning. The **Extension Springs** re-center the **Squeegee Support Assembly** and **Rear Squeegee Assembly** once the machine is again moving in a straight line.

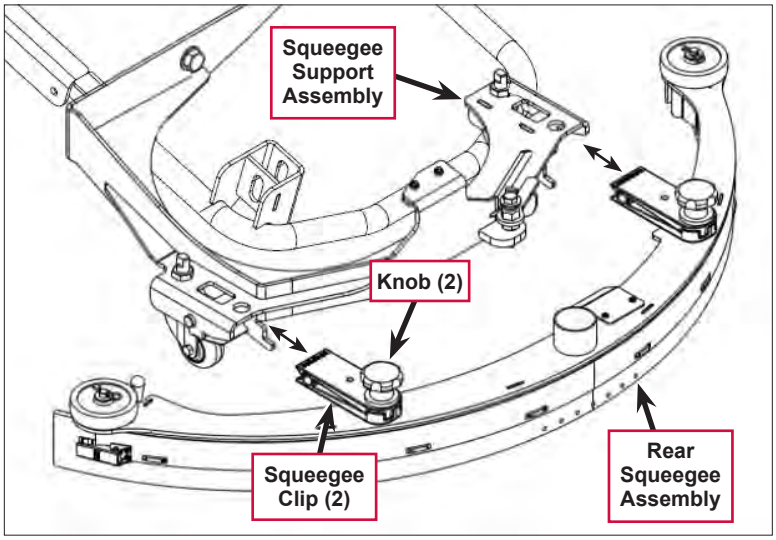


Maintenance and Adjustments

Warning! ***Before performing any squeegee maintenance or adjustments, make sure the key switch is off, the key is removed from the machine and the parking brake is engaged.***

To Remove and Reinstall the Squeegee Blades

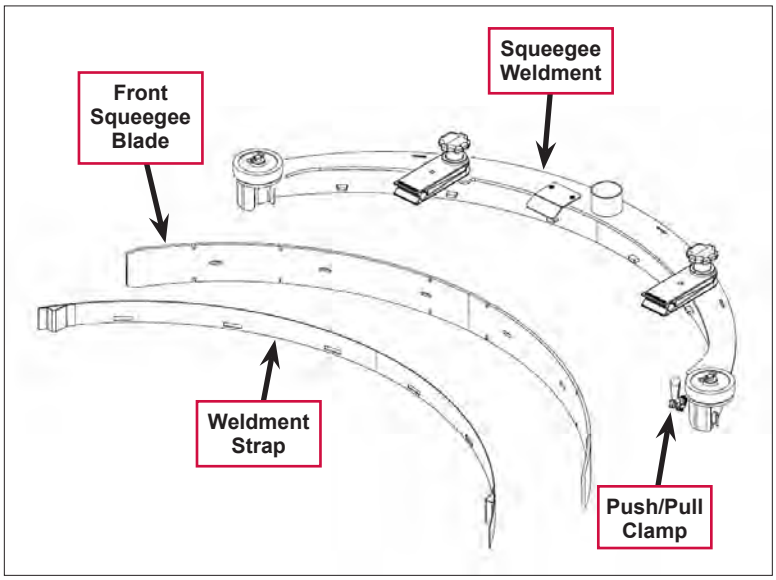
1. Raise the squeegee to its retracted position.
2. Disconnect the vacuum hose from the **Rear Squeegee Assembly**.
3. Loosen the two **Knobs** on the **Squeegee Clips** and pull the **Rear Squeegee Assembly** away from the **Squeegee Support Assembly**.



Note: *The **Squeegee Blades** have four usable edges and can be rotated end-for-end or top-to-bottom to position a new blade surface on the floor.*

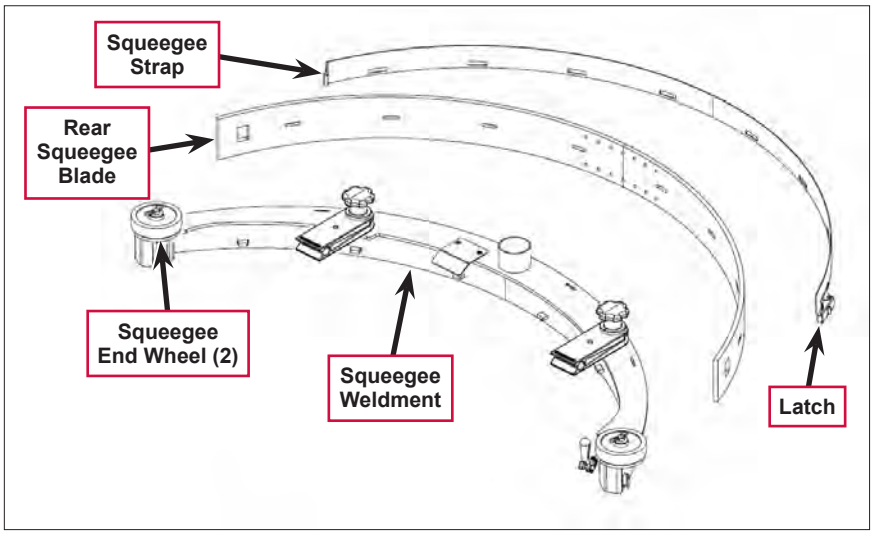
To Remove and Reinstall the Front Squeegee Blade

1. Release the **Push/Pull Clamp** and remove the **Weldment Strap**.
2. Remove the **Front Squeegee Blade** from the **Squeegee Weldment**.
3. Rotate the existing **Front Squeegee Blade** top-to-bottom or end-for-end to position a new blade surface on the floor, or install a new **Front Squeegee Blade** onto the **Squeegee Weldment** pins.
4. Reinstall the **Weldment Strap**, then secure the **Push/Pull Clamp**.



To Remove and Reinstall the Rear Squeegee Blade

1. Release the **Latch** and remove the **Squeegee Strap**.
2. Remove the **Rear Squeegee Blade** from the **Squeegee Weldment**.
3. Rotate the existing **Rear Squeegee Blade** top-to-bottom or end-for-end to position a new blade surface on the floor, or install a new **Rear Squeegee Blade** onto the **Squeegee Weldment** pins.
4. Reinstall the **Squeegee Strap**, then close the **Latch**.

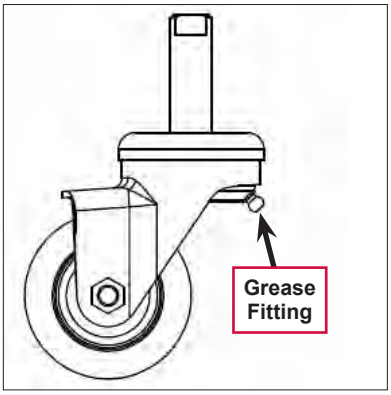


Squeegee End Wheels

Once a month apply light machine oil to the **Squeegee End Wheels**.

Squeegee Caster Wheel Bearings

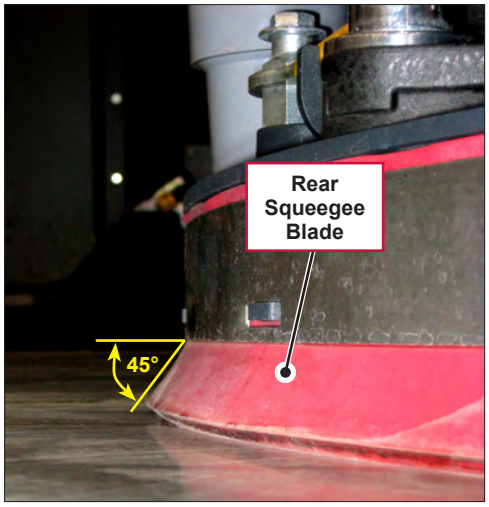
Once a month pump a small amount of grease into the **Grease Fitting** on both caster wheels on the squeegee support assembly until grease seeps out around the bearings.



To Adjust the Squeegee Tilt

1. Lower the squeegee and drive the machine forward a short distance so the squeegee assumes its normal operating angle.

2. Check the deflection angle of the **Rear Squeegee Blade**. It should be approximately 45 degrees to the floor surface as shown.



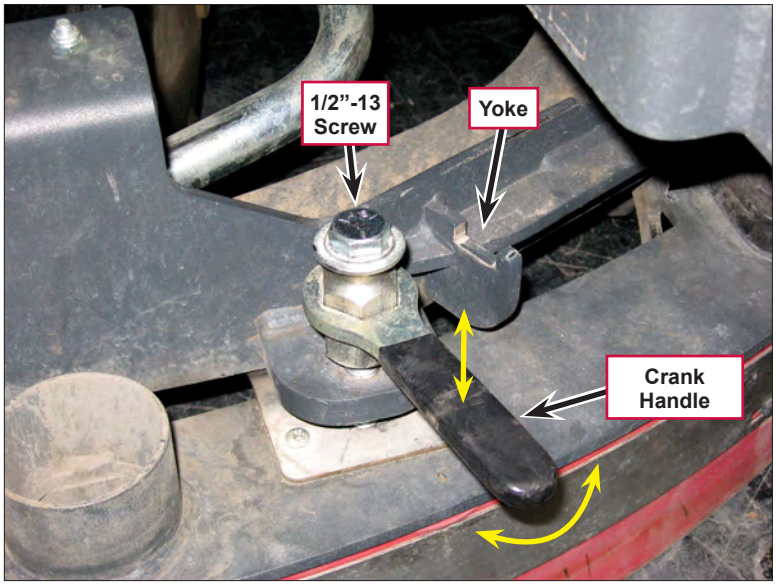
The ends of the squeegee should deflect as shown while still making full contact with the floor.

3. If the **Squeegee** tilt angle needs to be adjusted:

   a. Lift the **Crank Handle** out of the **Yoke**.

   b. Rotate the **Crank Handle** to raise or lower the **1/2”-13 Screw** as necessary so the squeegee blades are at the correct angle to the floor.

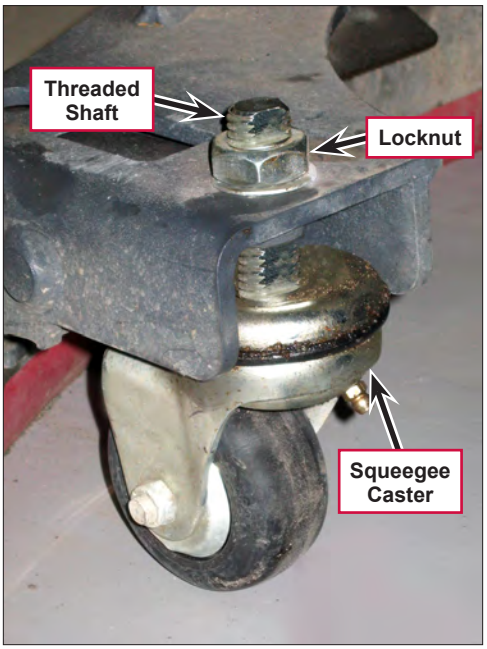
4. When the squeegee tilt adjustment is correct, replace the **Crank Handle** into the **Yoke**.



To Adjust the Squeegee Casters

The height of the **Squeegee Casters** may need to be adjusted to compensate for squeegee wear and to obtain the correct squeegee tilt angle. To adjust the height of a **Squeegee Caster**:

1. Loosen the **Locknut**.
2. Use a wrench on the flats of the **Threaded Shaft** to turn the **Threaded Shaft** to raise or lower the **Squeegee Caster** as necessary.
3. When the **Squeegee Caster** is at the correct height, tighten the **Locknut**.
4. Check the squeegee tilt angle and adjust as necessary. (Refer to the ***To Adjust the Squeegee Tilt*** section on the preceding page.)



Troubleshooting

Note: *You can use the Service Mode to toggle the various system components on and off to check for function. Refer to the* ***Control System/Service Mode*** *section for information on how to enter and use the Service Mode.*

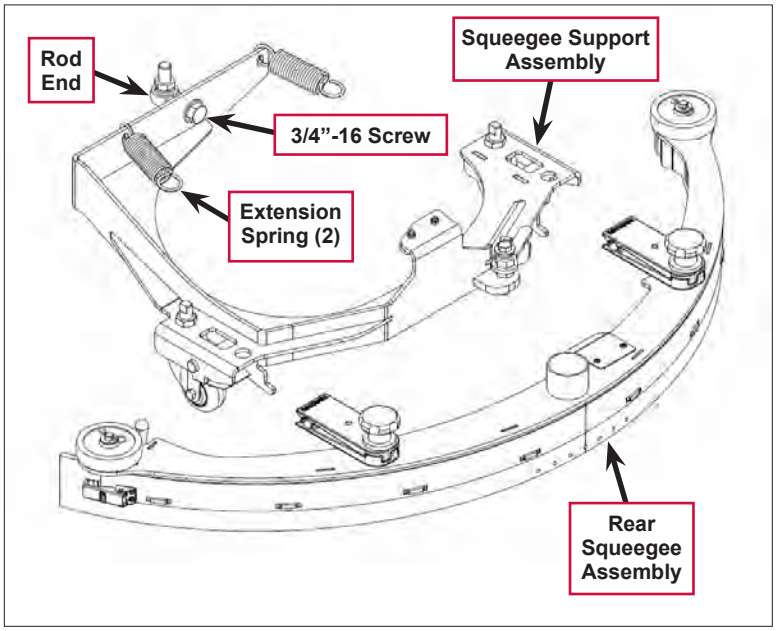
Problem	Cause	Correction
The squeegee will not rise or lower.	An interlock is not closed.	Before you start troubleshooting a specific system, check to make sure: • The emergency stop switch (**S15**) on the Operator control panel is disengaged (rotate clockwise). • The safety relay from the steering system (**K14**) is closed. • The seat switch (**S9**) is closed. • The battery interlock proximity sensor (**S13**) is closed.
	The squeegee actuator motor (**M12**) is not operating.	1. Check the wiring and connectors from the A1 Main Machine Controller to the squeegee actuator motor and repair as necessary. 2. Check the operation of the squeegee actuator motor. If the motor doesn't operate correctly, replace the squeegee actuator. 3. Check the voltage outputs from **J2-8** and **J2-9** on the A1 Main Machine Controller.
The squeegee is not picking up the water effectively.	There is a vacuum leak between the squeegee weldment and the recovery tank.	• Make sure the squeegee hose is installed correctly in the recovery tank and on the squeegee weldment. • Check the squeegee hose for damage or cracks and replace if necessary.
	The squeegee blade(s) is/ are worn out.	• Flip the squeegee blade(s) around to position a new blade surface on the floor. • Replace the squeegee blade(s).
	The squeegee actuator is not lowering the squeegee far enough onto the floor.	The squeegee down time is not set correctly. Refer to the ***Control System/Troubleshooting/Hidden Menus/User Options Menu*** section.
The squeegee is not picking up the water consistently along the entire length of the squeegee.	The squeegee tilt need to be adjusted.	Adjust the squeegee tilt. (Refer to the ***Maintenance and Adjustments/To Adjust the Squeegee Tilt*** section.

Removal and Installation

Warning! ***Before removing or reinstalling any machine components, make sure the key switch is off, the key is removed from the machine and the parking brake is engaged.***

To Remove and Reinstall the Squeegee Support Assembly

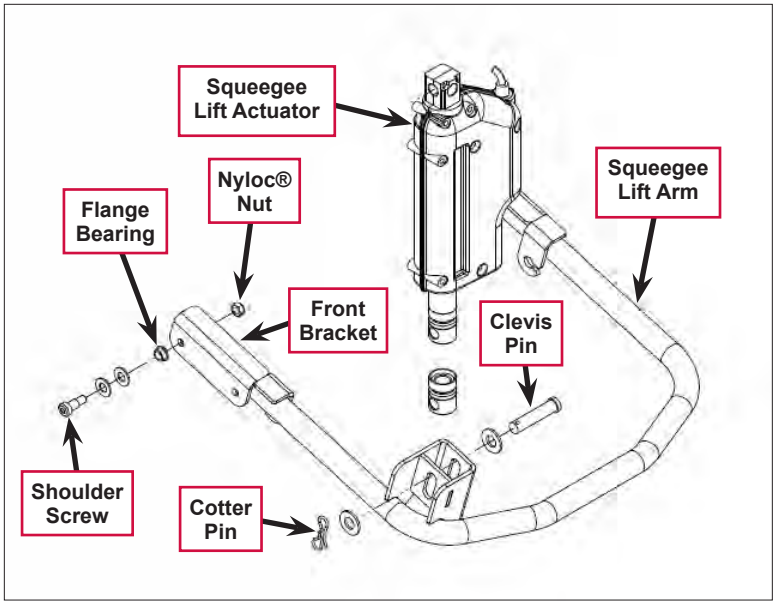
1. Remove the **Rear Squeegee Assembly**.
2. Disconnect the **Extension Springs** from the **Squeegee Support Assembly** using a spring puller. (See the ***Special Tools*** section.)
3. Remove the **3/4"-16 Screw** holding the **Squeegee Support Assembly** to the **Rod End**.
4. Carefully remove the **Squeegee Support Assembly** from the machine.
5. Reinstall the **Squeegee Support Assembly** by following the above steps in reverse order.



Note: *Use removable Loctite® thread sealer when reinstalling the* ***3/4"-16 Screw****. Tighten the* ***3/4"-16 Screw*** *to 270 ft/lbs.*

To Remove and Reinstall the Squeegee Lift Arm

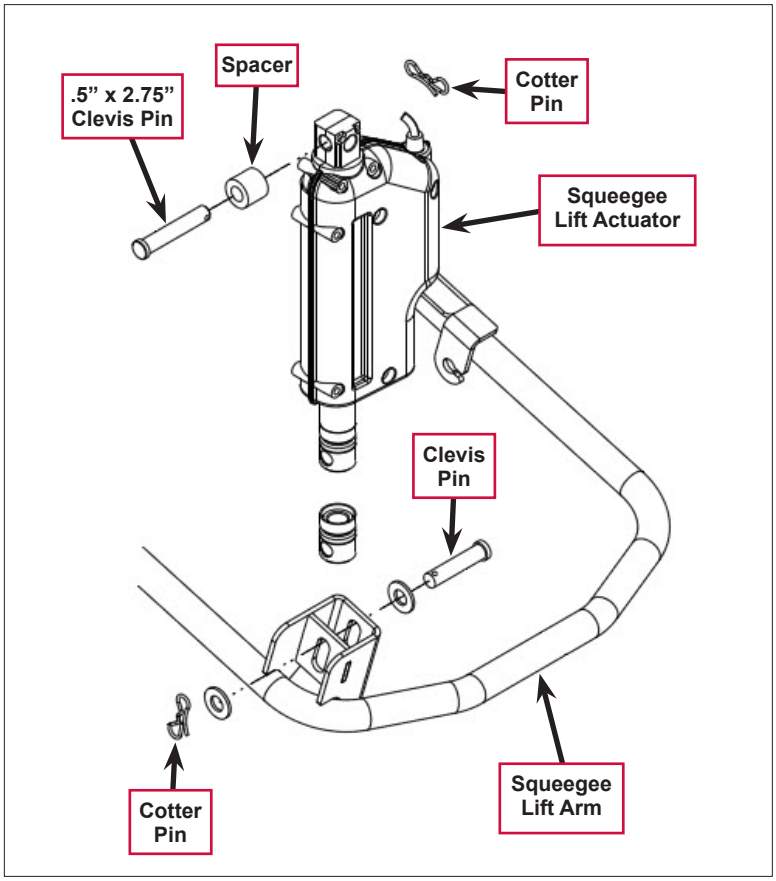
1. Remove the **Rear Squeegee Assembly** and **Squeegee Support Assembly**.
2. Disconnect the **Extension Springs** from the **Squeegee Lift Arm**.
3. Remove the **Cotter Pin**, washers and **Clevis Pin** connecting the **Squeegee Lift Actuator** to the **Squeegee Lift Arm**.
4. Remove the **Shoulder Screws**, flat washers, **Flange Bearings** and **Nyloc® Nuts** connecting the **Front Brackets** to the machine frame, then remove the **Squeegee Lift Arm** from the machine.
5. Reinstall the **Squeegee Lift Arm** by following the above steps in reverse order.



To Remove and Reinstall the Squeegee Lift Actuator

1. Remove the recovery tank.
2. Remove the squeegee tool assembly. (This will reduce the weight on the **Squeegee Lift Arm**.)
3. Disconnect the lift actuator electrical connector.
4. Remove the **Cotter Pin**, washers and **Clevis Pin** connecting the **Squeegee Lift Actuator** to the **Squeegee Lift Arm**.
5. Remove the **Cotter Pin**, **.5" x 2.75" Clevis Pin** and **Spacer** connecting the **Squeegee Lift Actuator** to machine frame and remove the **Squeegee Lift Actuator** from the machine.
6. Reinstall the **Squeegee Lift Actuator** by following the above steps in reverse order.

Note: *The **Squeegee Lift Actuator** does not require adjustment after installation.*



Specifications

Component	Specifications
Squeegee Tool Assembly	
Squeegee Blade, Front, Red Gum	Material - Linatex 40 Color - Red Hardness - 40 ±5 Shore A Durometer Tensile Strength - 3000 Psi Minimum Elongation - 600% Minimum
Squeegee Blade, Rear, Red Gum	
Squeegee Lift Actuator	Dynamic Load - 200 lbs. maximum
	Static Load - 250 lbs. maximum
	Restraining Torque - Actuator is internally restrained
	Amperage - 3 Amps at rated dynamic load
	End of Stroke - Actuator has internal limit switches connected to the motor to shut off power at ends of stroke
	Overload Protection - Ball detent clutch with load rating between 250 and 500 lbs.
	Thermal Protection - Automatic resetting thermal breaker enclosed in motor housing.
	Wiring Polarity: • To extend actuator, connect red lead to positive and orange lead to negative. • To retract actuator, connect orange lead to positive and red lead to negative.

Special Tools

A spring puller is recommended to remove the Extension Springs from the Squeegee Support Assembly and Squeegee Lift Arm when removing these components. There are several types of spring pullers - a typical example is shown here.	

Steering System

Functional Description

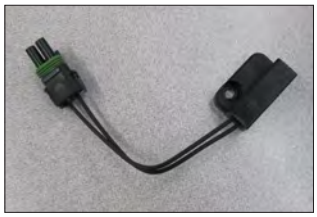
Summary

The steering system utilizes steer by wire technology. The major electrical components are the Steering Controller, Steering Wheel Rotation Sensor, Steering Actuator and the Steering Travel Limit Switches. The Steering Controller receives input signals from the Steering Wheel Rotation sensor that tell it which direction the steering wheel is turning and how fast it is rotating. Based on these inputs the Steering Controller drives the Steering Actuator Motor with a three phase alternating current to rotate a gear. The gear is meshed to a large ring gear that rotates the drive wheel assembly either right or left. The Steering Controller also monitors two travel limit switches (proximity switches) that signal when the drive wheel has steered to is maximum desired angle in either direction.

Steering Controller

Steering Wheel Rotation Sensor

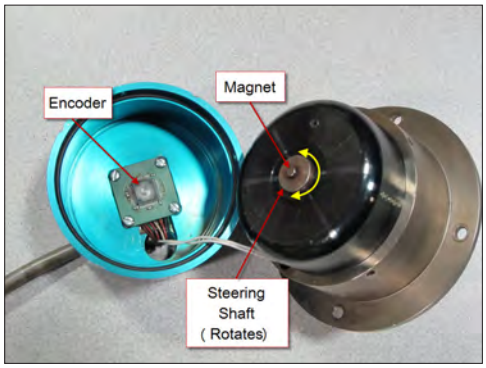
Steering Actuator

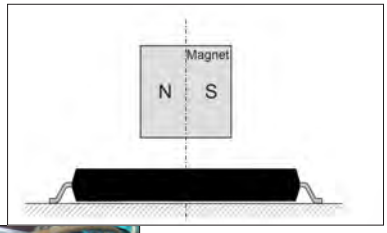


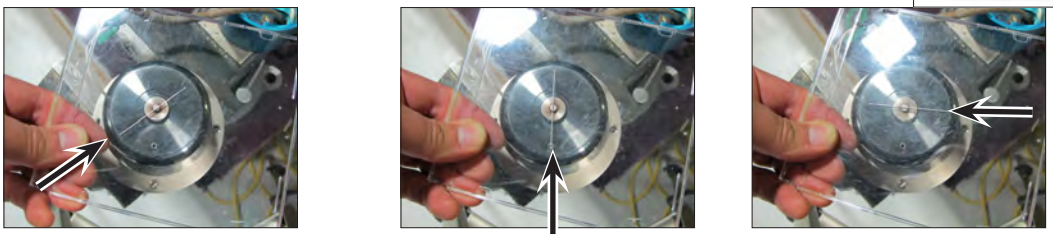
Proximity Sensor - Travel Limit Switch

Steering Wheel Rotation Sensor

The Steering Wheel Rotation Sensor has an internal "encoder" that translates steering wheel rotation information into four digital signals. The end of the steering shaft has a special "diametrically polarized" magnet on it. The line of separation between the north and south magnetic poles rotates in close proximity to the encoder. The three images below show how a wire on a clear plastic CD case rotates as the shaft rotates. The encoder "reads" the movement of the magnetic fields and creates a four 5v square wave signals. There are two pairs of signals. For each pair, when the steering wheel rotates, one of the signals switches before the other so that the controller can tell which direction the steering wheel is being turned. The second pair of signals provides "redundant" information.

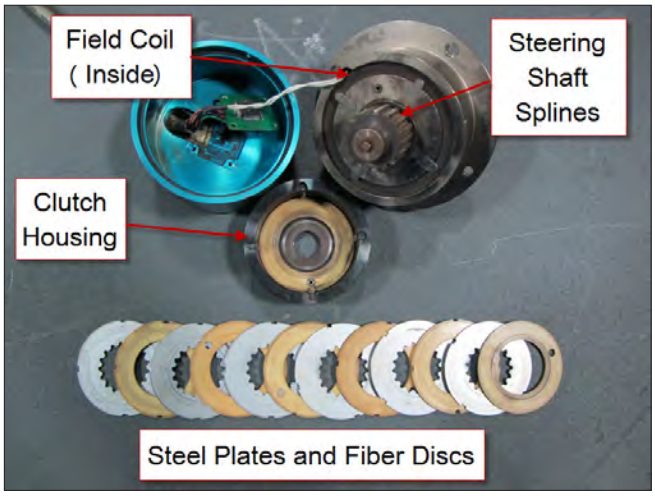


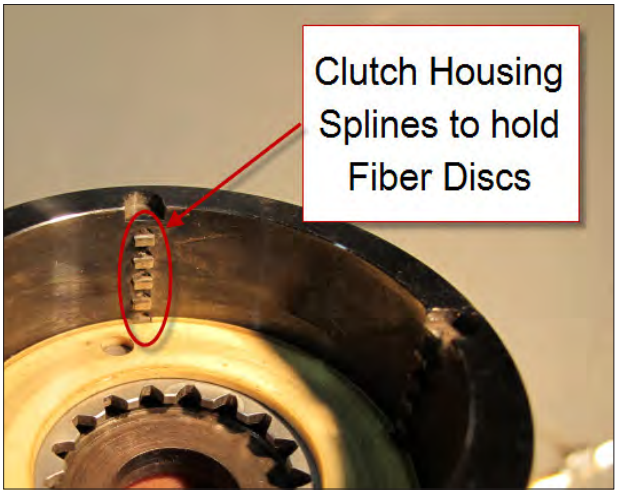




The wire rotates with the magnetic field as the steering wheel rotation sensor shaft is turned

The Steering Wheel Sensor also has an electromagnetic clutch called a “Torque Feedback Device” which provides steering feel to the operator. The clutch consists of multiple fiber discs and steel plates which are alternately stacked. The steel plates are splined to the steering shaft so they always rotate with the shaft. The fiber discs are splined to the clutch housing and are held stationary. When electrical current flows through the clutch field coil winding, the magnetic field generated pulls the plates together creating friction between the plates and discs that resists steering wheel movement. The resistance is proportional to the current flow. The Steering Controller regulates the amount of current flow to provide the right steering “feel”.

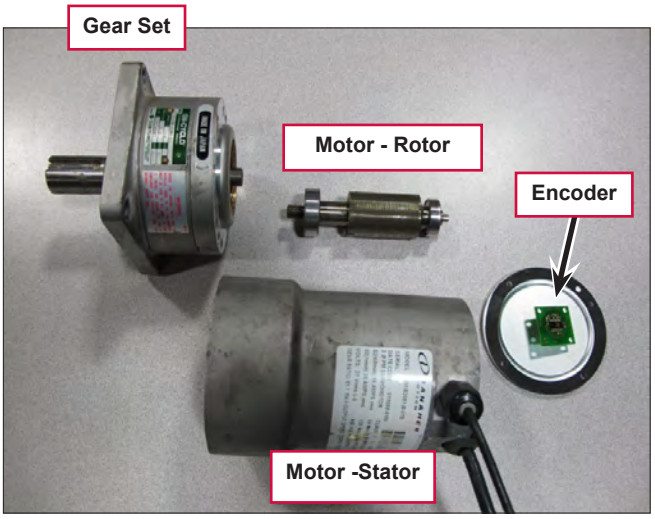




Steering Actuator

The Steering Actuator consists of a motor, gear set and a position sensor. The motor operates on three phase AC (Alternating Current) and is a “brushless” design. It rotates a gear set that drives the output shaft. The output shaft is keyed to a drive gear which drives a large “ring” gear to turn the rear drive wheel assembly. There is also a sensor inside the motor that reports position and rotation information to the Steering Controller. This information provides feedback to the controller so that it can verify that the motor actually moved as it was commanded to.

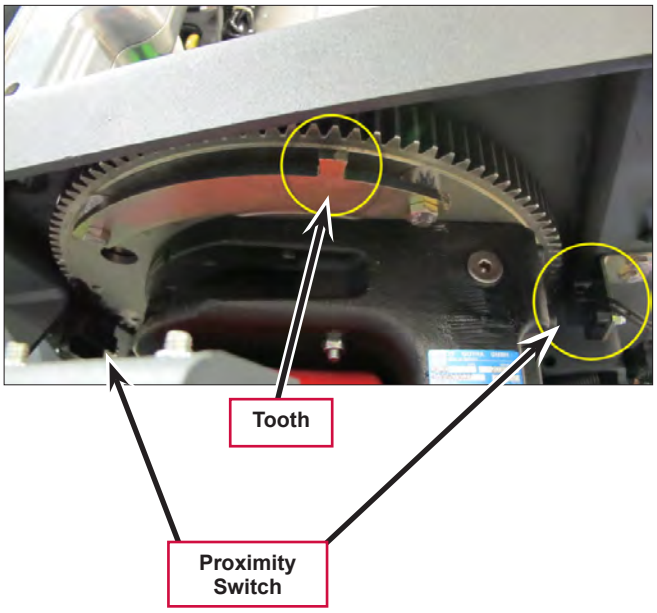
The Steering Actuator has an internal “encoder” that translates motor rotation information into digital signals. The end of the motor shaft has a special “diametrically polarized” magnet on it. The line of separation between the north and south magnetic poles rotates in close proximity to the encoder. The encoder “reads” the movement of the magnetic fields and creates a two 5v square wave signals. As the motor rotates, one of the signals switches before the other so that the controller can tell which direction the motor is rotating.



Steering Actuator

Steering Travel Limit Switches

The Steering Travel Limit Switches are magnetic "proximity" switches that are normally open. They are mounted on each side of the frame. There is a bracket mounted on the drive wheel steering ring gear with a "tooth". As the gear rotates, the "tooth" moves with it. When the tooth lines up with one of the proximity switches, its internal switch closes to let the controller know it should stop moving in that direction.

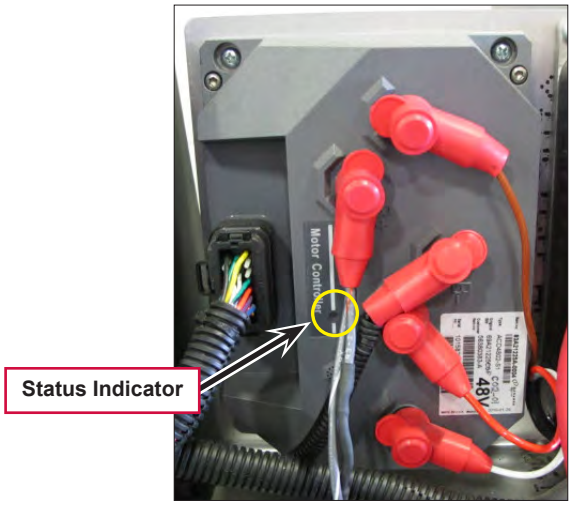


Steering Controller

The steering controller is the heart of the steer by wire system. It operates the steering actuator based on input requests from the steering wheel rotation sensor and the travel limit proximity switches. It has robust self diagnostics to protect itself and shut down the steering system if a serious error occurs. It is a sealed unit with no serviceable parts inside. It is capable of storing DTCs (Diagnostic Trouble Codes). See the ***Troubleshooting*** section for more information.

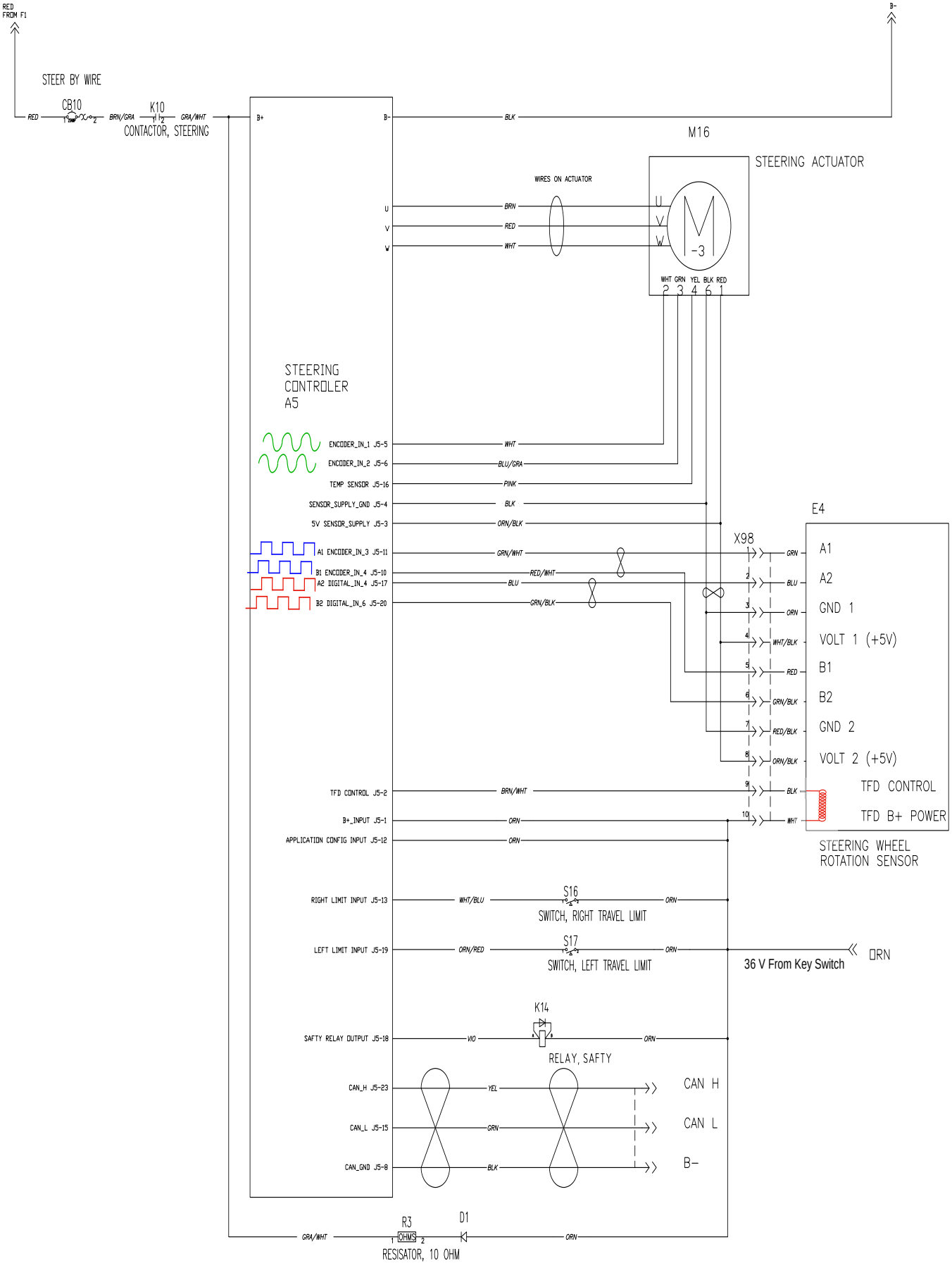
There is a green LED "Status Indicator" built into the controller that provides important information to the service technician. Note: you must be looking straight at it and not from an angle for it to be visible.

LED Indicator State	Condition
Off	The Controller is not powered up, or is powered but not functional.
Blinking slowing (1HZ)	Start-up mode.
Blinking rapidly (10HZ)	The system is disabled due to an error condition.
On steady	The system is fully functional with no error condition.



Steering Controller

Steering System Wiring Diagram

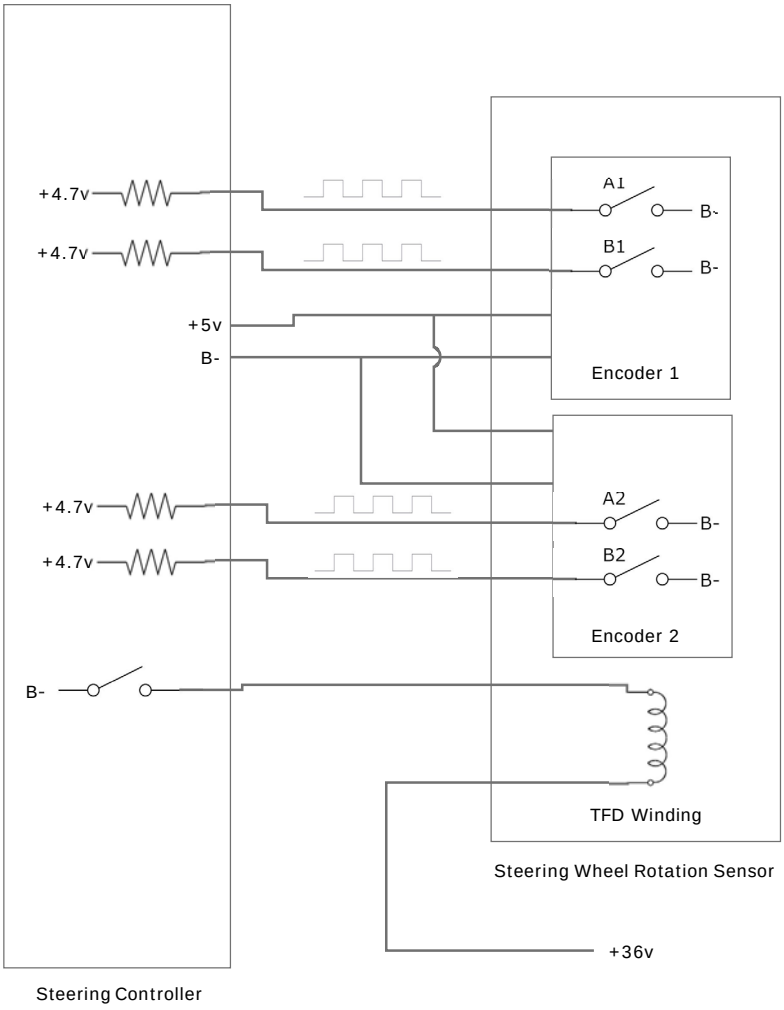


Circuit Description

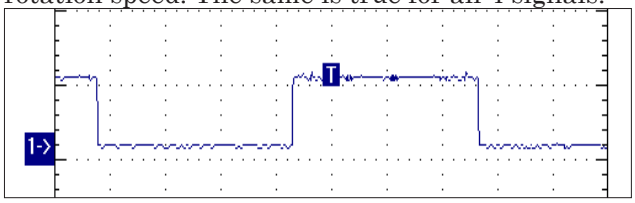
The steering controller power has more than one power supply. The main heavy current power sources are bolt on lugs that supply both battery positive and negative connections. These connection points are clearly labeled on the controller. This power is used to convert the direct current to 3 phase alternating current, which drives the actuator motor. There is also a switched power source that goes to J5-1. This power begins at the battery positive terminal goes through circuit breaker #4, through the ignition switch, through the seat switch and then to connector J5 pin 1. This is used to "wake up" the controller and supply power for lower current circuits. Power is also supplied to J5 pin 12 but this is not truly a power supply. It is used to identify what machine the controller is attached to.

The steering controller sends a 5 volt power supply out of J5-3 which provides power to the steering actuator encoder at pin 1 and the steering wheel rotation sensor encoder pins 4 and 8. The steering rotation sensor encoder has 2 grounds at pins 3 and 7. These are not connected directly to battery negative but go to steering controller J5-4. The controller provides a "clean filtered ground" for the encoder circuits. The encoder built into the steering actuator also has a ground at pin 6 which is grounded through the controller J5-4.

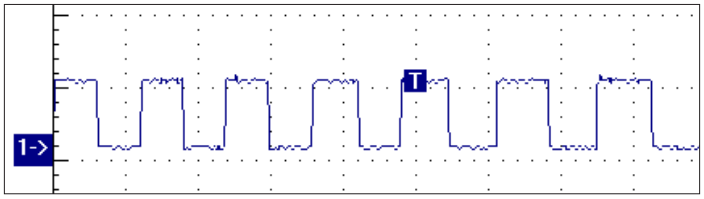
The steering wheel rotation sensor encoder has 4 "internal switches" (See image below) Each switch is fed approximately 5 volts (4.7v) from the steering controller on its own wire. As the steering wheel rotates, the switches cycle on and off to ground causing the 5v to drop to 0v and back up again. This creates four separate 5 volt square wave signals which, are "read" by the steering controller. Note that the encoder circuits use "twisted pair" wiring to eliminate electrical noise.



As the steering wheel rotates, the A1 signal switches back and forth from 0v (low) to 5v (high). When viewed on a scope (oscilloscope) it looks like a “square wave” pattern. When the steering wheel rotation is slow, the switching frequency is slow. This is seen as longer and fewer square wave patterns on the scope screen. When the steering wheel rotation is faster, the switching frequency is faster. This is seen as more but shorter patterns on the scope screen. This changing frequency is how the controller “sees” the steering wheel rotation speed. The same is true for all 4 signals.

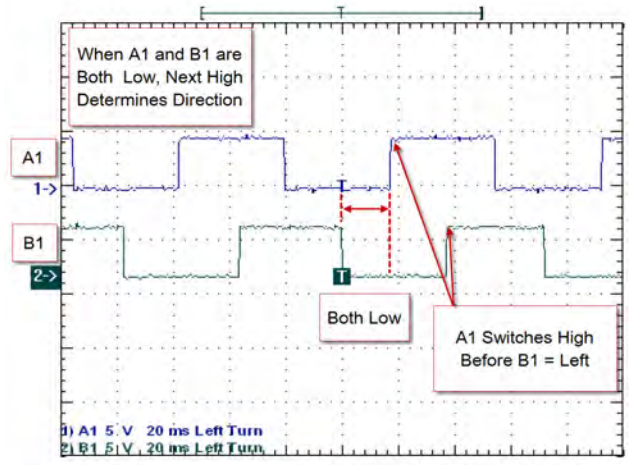


Slow Rotation

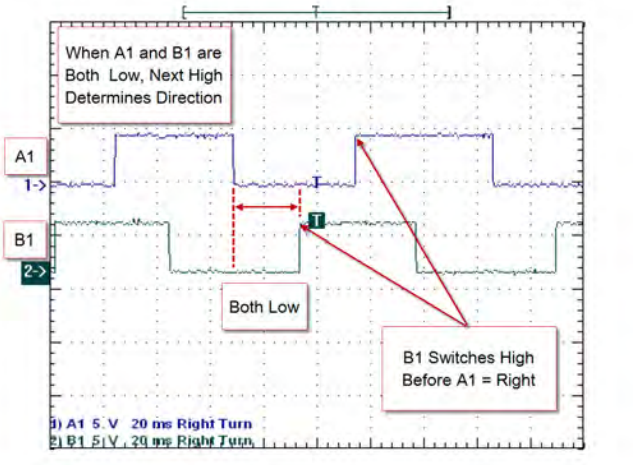


Fast Rotation

In order to determine which direction the steering wheel is rotating, the controller “looks” at two signals (A1 and B1) at a time. These signals are intentionally offset (out of phase) from one another. This is “physically” built into the way the encoder works. When A1 and B1 are both reporting “low”, the controller will be able to tell which direction the steering wheel is rotating by which of the signals goes “high” first. If A1 switches high first, then the wheel turning left. If B1 switches first, the wheel is turning right. A2 and B2 are used as an extra (redundant) pair of signals.


When A1 and B1 are Both Low, Next High Determines Direction
A1
1->
B1
2->
T
Both Low
A1 Switches High Before B1 = Left
1) A1 5 V 20 ms Left Turn
2) B1 5 V 20 ms Left Turn

Left Turn

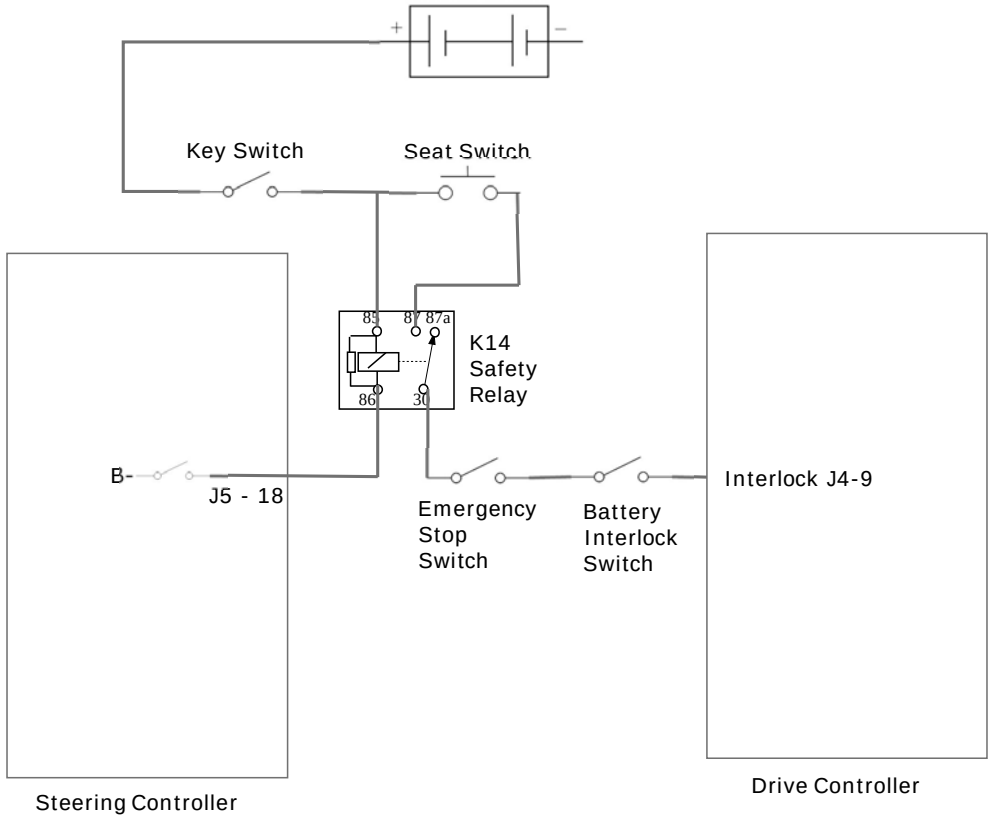

When A1 and B1 are Both Low, Next High Determines Direction
A1
1->
B1
2->
T
Both Low
B1 Switches High Before A1 = Right
1) A1 5 V 20 ms Right Turn
2) B1 5 V 20 ms Right Turn

Right Turn

The steering wheel sensor also contains a TFD (Torque Feedback Device). The TFD is powered on the same circuit as the controller J5-1. Power is supplied to a coil winding inside the TFD on sensor pin 10. The power flows through the coil, out sensor pin 9 and into controller J5-2. Inside the controller, there is a “switch” that opens and closes rapidly to provide a “controlled” ground for the coil. When a ground is supplied, current flows through the winding and creates a magnetic field. As the percentage of ground time is increased, the current flow increases causing a stronger magnetic field to be created in the TFD. The magnetic field creates a “clamping” force on the TFD clutch pack, which in turn, provides “steering feel” to the operator.

There are two travel limit proximity switches. Each switch receives voltage on the same circuit as J5-1 (through the seat switch). The switches are normally open. When the cam “tooth” lines up with the switch, the switch closes sending the voltage on to the steering controller. The right travel limit switch is connected to J5-13. The left travel limit switch is connected to J5-19

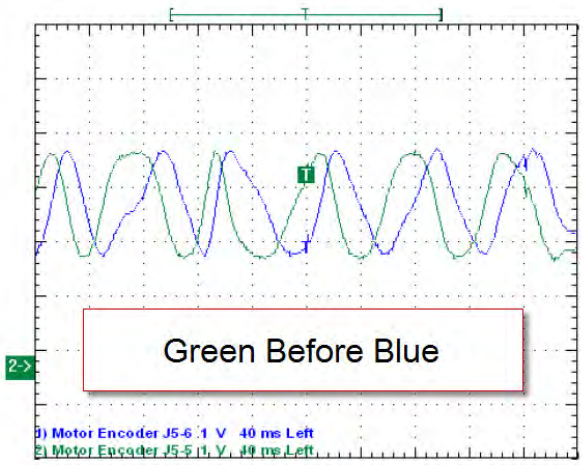
The steering controller controls a safety relay (K14) to shut down the drive wheel system in the event that there is a serious steering system error. The relay coil receives battery voltage from the key switch (The same as J5-1). The voltage flows through the relay coil and on to the controller J5-18. Inside the controller there is a "switch" that closes to battery negative to energize the relay. The relay contacts close allowing battery voltage to the drive controller interlock switch circuit J4-9. In the event of a serious steering system error, the steering controller opens its internal switch to de-energize the safety relay coil. This causes the relay contacts to open and removes the power supply from the drive motor controller. This shuts down the drive wheel system.



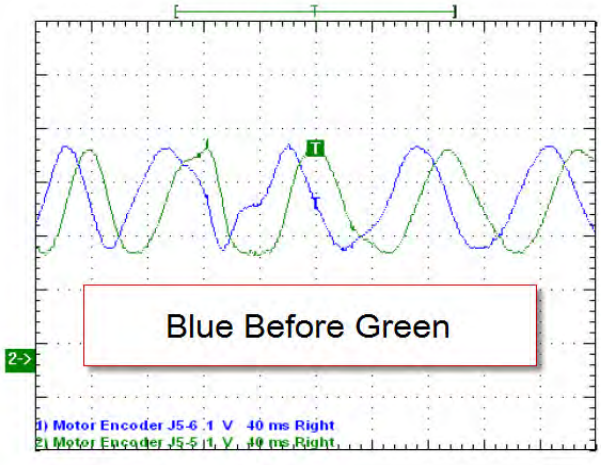
The steering controller can communicate with other devices via a "CAN bus". The CAN bus wires are at J5-23, J5-15 and J5-8.

The steering actuator motor has 3 "stator" windings that are interconnected. These wires are the "working wires" of the motor. The controller supplies AC voltage and current to these winding to create a magnetic field that will act upon the rotor magnetic field and apply torque to spin the rotor. The controller is capable of switching the current to the windings on and off in specific order to make the motor turn either clockwise or counterclockwise and control the speed of the motor. The motor windings are wired directly to the bolt on lugs of the steering controller. They are clearly marked "U", "V" and "W".

The Steering Motor incorporates an encoder that reports both direction and speed information to the controller. The operation is similar to the steering wheel rotation sensor encoders however; there is only a single “pair” of signals and the pattern is not square. The frequency of the signal provides speed information. The signals are slightly offset to indicate rotation direction. The encoder receives a 5v power supply at pin 1 from the steering controller pin J5-3. The encoder is grounded on pin 6 through the steering controller J5-4. The encoder sends a wave signal out of pin 2 to controller J5-5 and out of pin 3 to controller J5-6.



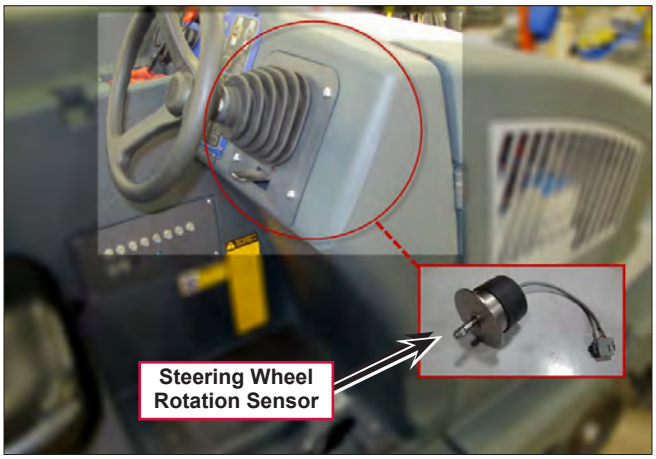
Left Turn

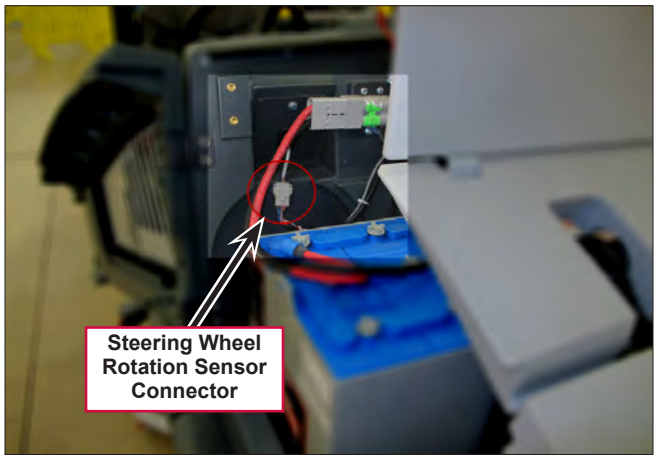


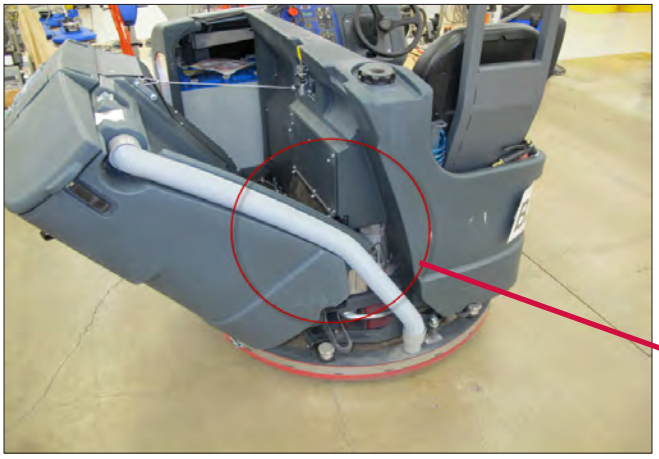
Right Turn

Component Locations

- Steering Wheel Rotation Sensor
- Steering Wheel Rotation Sensor Connector
- Steering Actuator - Rear of machine in front of drive wheel motor.
- Steering Controller - Left rear of machine







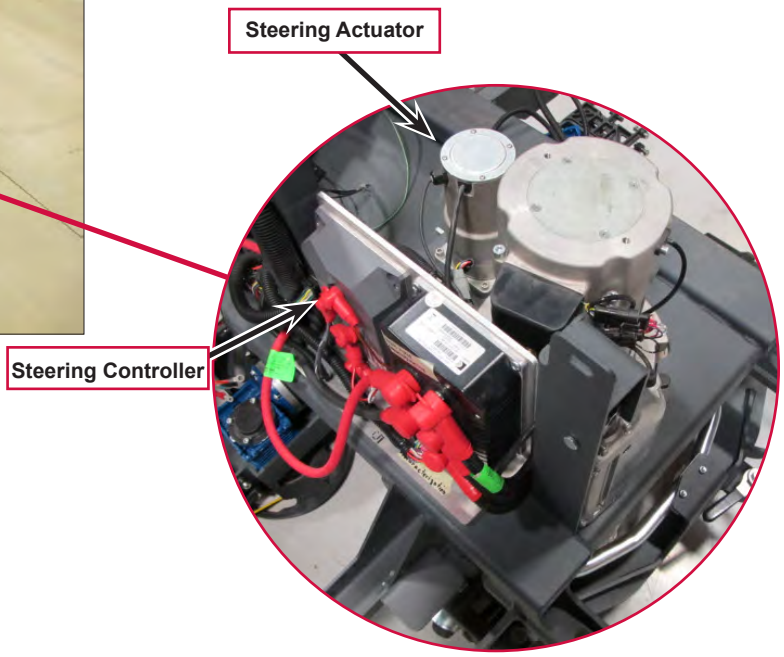


Photo taken without tanks

Maintenance and Adjustments

Check bolt torque of wiring connections at the Steering Controller every six months.

Troubleshooting

If a problem occurs with the steering system, begin by checking the Status LED condition on the steering controller and for steering system DTCs (Diagnostic Trouble Codes). If the Status LED does not light, check the power and ground supplies for the controller first. If the Status LED is flashing and there are DTCs, diagnose the cause of the DTC. If there are no codes, follow the symptom troubleshooting.

Diagnostic Trouble Codes (DTCs)

The steering controller monitors the steering system to protect itself and disable the steering system if necessary. When a serious error is detected, the controller sets a DTC (Diagnostic Trouble Code) and communicates the code to the main machine controller via the CAN bus. The main machine controller will set a “machine level” code of 50 and tell the control panel to display it to the operator. Machine code 50 means that there is a DTC set in the steering system. In order to get the specific steering system DTC, enter the “hidden menu” configuration display function.

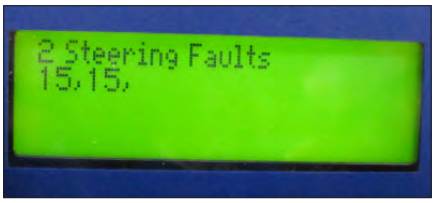
To retrieve steering system codes from the “hidden menu”:

1. Press and hold the hazard warning flasher button down while turning on the key. Wait until the “Configuration Display” screen appears, then release the button.

2. Press and release the scrub pressure decrease button several times until the cursor arrow is pointing at “15 Fault Recall, then press the scrub button to enter the fault recall menu.

3. Press the scrub pressure decrease button to scroll down to “2 Steering Faults”, then press the scrub button.

4. The Steering faults menu displays all of the codes that have ever been set in the system. The codes are displayed in “reading order”, separated by commas and are sorted with the most recent at the top left. See the Diagnostic Trouble Code Table below to look up what the code means.



5. To exit, press the solution button.

Diagnostic Trouble Code Table

DTC	Error Source	Description	Check
0	AC Current – Excessive	The hardware detected excessive current flow in the steering actuator motor circuits.	Actuator - shorted/burned stator windings. Wiring (U, V & W) - Shorted to ground or one another. Steering Controller - Internal Short Note: Can also be caused by too low DC supply voltage on B+.
1	DC Power Supply - Low Voltage	The software detected that the DC power supply (B+ and B-) voltage is too low.	Battery Positive and Negative connections at source and controller Battery Positive and Negative cables
2	DC Power Supply - High Voltage	The software detected that the DC power supply (B+ and B-) voltage is too high.	Battery Positive and Negative connections at source and controller Battery Positive and Negative cables Note: If there is too much resistance between the controller and the battery during regenerative braking, the voltage can climb.
3	DC Power Supply - High Voltage	The hardware detected that the DC power supply (B+ and B-) voltage is too high.	Battery Positive and Negative connections at source and controller Battery Positive and Negative cables Note: If there is too much resistance between the controller and the battery during regenerative braking, the voltage can climb.
4	DC Power Supply Insufficient	The B+ and B- cables did not supply enough current to charge a capacitor inside the controller within 10 seconds.	Battery Positive and Negative connections at source and controller Battery Positive and Negative cables

DTC	Error Source	Description	Check
5	Motor Temperature High	The Motor Temperature is above 180 °C (356 °F)	Restrictions to steering actuator movement. Actuator - temperature sensor accuracy
6	Steering Controller Temperature High	The Steering Controller Temperature is above 125 °C (257 °F)	Restrictions to steering actuator movement. Actuator - temperature sensor accuracy
7	Steering Wheel Rotation Sensor Circuits	One or more of the four digital “encoder” signals is missing or is not occurring in the correct sequence with its paired partner.	Sensor - All 4 encoder signals for proper high voltage to low voltage switching as the steering wheel is turned slowly. Open wiring, intermittent connections. Shorted wiring - to one another or to ground. 5v power supply from steering controller to both encoder pairs B- supply for both encoders through the steering controller
8	CAN Bus communication lost	The steering controller is not receiving CAN Bus messages.	Can Bus Wiring Controller - termination resistor Note: The steering controller does not require any CAN bus messages to operate the steering system.
9	Controller Hardware Fault	The internal current sensor is out of calibration	Controller Electrical Connections Controller
10	Internal 15V supply voltage is low	The internal 15V supply voltage on the board is too low	Controller Electrical Connections Controller
11	Internal 5V supply voltage is low or high	The internal 5V supply voltage on the board is either too low or too high.	Controller Electrical Connections Controller
12	Torque Feedback Device – Excessive Current	Excessive current flow through the torque feedback device circuit.	Steering Wheel Rotation Sensor, Torque Feedback Device - Shorted winding. Short to B+ on TFD control circuit

DTC	Error Source	Description	Check
13	AC Current – Excessive	The software detected excessive current flow in the steering actuator motor circuits.	Actuator - shorted/burned stator windings. Wiring (U, V & W) - Shorted to ground or one another. Steering Controller - Internal Short Note: Can also be caused by too low DC supply voltage on B+.
14	Position calibration error	The “Center Position” has not been able to be established. (Not properly calibrated to right and left travel limit switches.) This error occurs when the steering controller calculated actuator motor position indicates the mechanism is beyond a steering travel limit switch position but the switch has not indicated that the end has been reached. (The steering controller believes that the physical position of the steered wheel is beyond the “soft limit” that should have been indicated by the steering travel limit switch closing.) This error also occurs when a steering travel limit switch closes indicating that the limit of travel has been reached but the controller calculated position indicates that the mechanism should not be near the limit of travel.	Excessive backlash in steering gears Controller Configuration Steering Limit Switches Steering Limit Switch wiring
15	Steering Actuator - Encoder Circuits	Steering Actuator encoder feedback error.	Wiring - between actuator encoder and controller Actuator - Encoder Signals
21	Current regulator supervision	Difference between set value and actual value for current regulator are above limit.	Obstructions to steering actuator gear rotation. Excessive gear backlash Loose connection in steering actuator encoder wiring. Steering Actuator
22	Position regulator supervision	Difference between set value and actual value for position regulator are above limit.	Obstructions to steering actuator gear rotation. Excessive gear backlash Loose connection in steering actuator encoder wiring. Steering Actuator

DTC	Error Source	Description	Check
23	Motor cable not connected (U,V or W wire open)	One or more of the motor cables between the steering actuator and the steering controller are not connected	Wiring - U, V and W cables and connections.
24	Position calibration error	This error occurs when the steering controller calculated actuator motor position indicates the mechanism is beyond a steering travel limit switch position but the switch has not indicated that the end has been reached. (The steering controller believes that the physical position of the steered wheel is beyond the “soft limit” that should have been indicated by the steering travel limit switch closing.) This error also occurs when a steering travel limit switch closes indicating that the limit of travel has been reached but the controller calculated position indicates that the mechanism should not be near the limit of travel. .	Excessive backlash in steering gears Controller Configuration Steering Limit Switches Steering Limit Switch wiring
25	Position sensor	This error occurs when the steering controller calculated actuator motor position indicates the mechanism is beyond a steering travel limit switch position but the switch has not indicated that the end has been reached. (The steering controller believes that the physical position of the steered wheel is beyond the “soft limit” that should have been indicated by the steering travel limit switch closing.) This error also occurs when a steering travel limit switch closes indicating that the limit of travel has been reached but the controller calculated position indicates that the mechanism should not be near the limit of travel. .	Excessive backlash in steering gears Controller Configuration Steering Limit Switches Steering Limit Switch wiring
26	Speed regulator supervision	Difference between set value and actual value for speed regulator are above limit.	Obstructions to steering actuator gear rotation. Excessive gear backlash Loose connection in steering actuator encoder wiring. Steering Actuator
27	Induction speed estimation supervision	The estimated speed is above limit	

Symptom Troubleshooting (No DTC stored)

Steering Inoperative - Steering Controller Status LED is Blinking Rapidly

Check for steering system codes.

Steering Inoperative - Steering Controller Status LED is Off

Check power and ground supplies to the steering controller.

Steering Inoperative - Steering Controller Status LED is On Steady

Check each input to make sure it is operating correctly. (Refer to the ***Specifications*** Section, ***Shop measurements*** information)

- Steering wheel rotation sensor - Each encoder signal should switch between approximately 5 volts and 0 volts as the steering wheel is turned very slowly.
- Travel limit switches - There should be approximately 0 volts at one or both inputs at the controller.

No “Steering Feel”

Possible Causes:

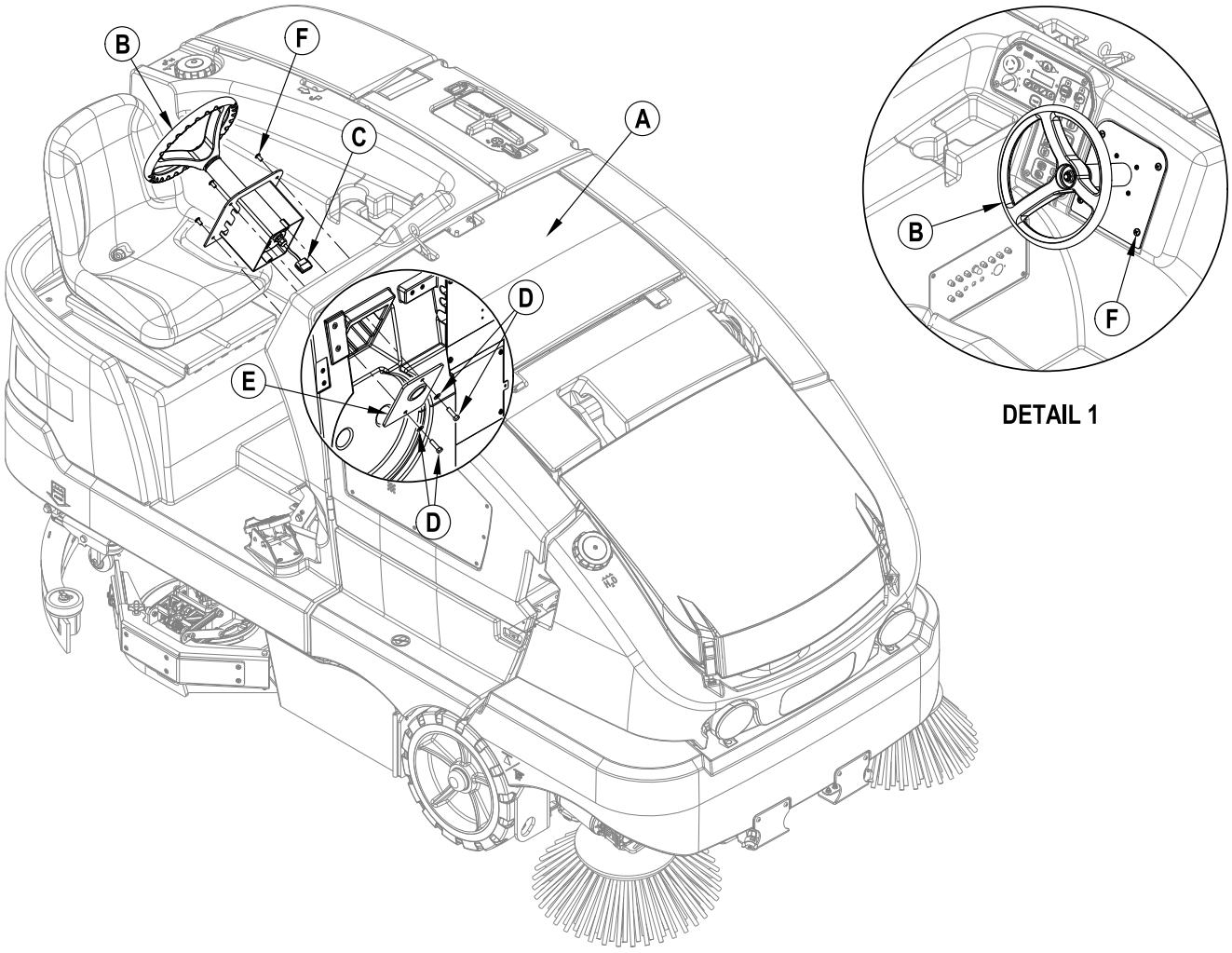
- Steering wheel rotation sensor (TFD) - Check for open circuit in the TFD coil.
- Steering Controller - Not controlling TFD
  - Check the power supply into the TFD
  - Check the ground control voltage. It should be around 24 volts.
  - Check the current draw of the TFD coil.
    - Approximately 400 mA = Regular steering feel.
    - Approximately 900 to 1000 mA = steering feel at “soft stop”.
    - If the current draw is normal but the steering feel is not, replace the steering wheel rotation sensor.

Steering Wheel Is Difficult To Turn

Unplug the steering wheel rotation sensor. If the steering wheel is still difficult to turn, there is a mechanical binding in the steering wheel rotation sensor TFD.

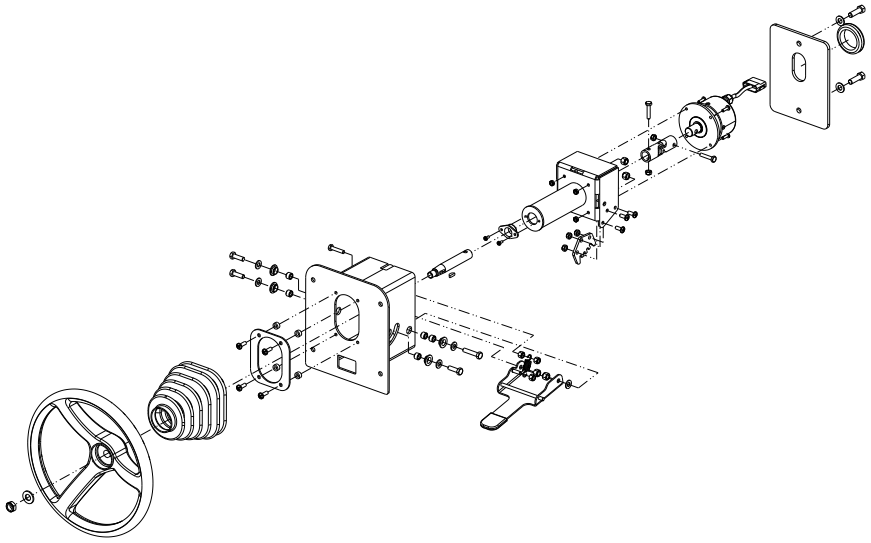
Removal and Installation

Steering Wheel Assembly



1. Turn the machine off, set the parking brake and disconnect the 36 V battery main power plug.
2. Lift the Rear Engine Cover (A) to access the Main Harness Connector and Steering Clamp Plate (E) on the Steering Assembly (B) as shown.
3. Unplug the Torque Feedback Device Connector (C) from the Main Harness.
4. Remove the hardware (D) and Steering Clamp Plate (E) from the Steering Assembly (B).
5. Remove and save the (4) Pan Screws (F) and remove the Steering Assembly (B) See Detail 1.

Steering Wheel Rotation Sensor



Caution! ***Do not hit steering wheel shaft with a hammer to remove the steering wheel. Doing so may damage the encoder inside the steering wheel sensor.***

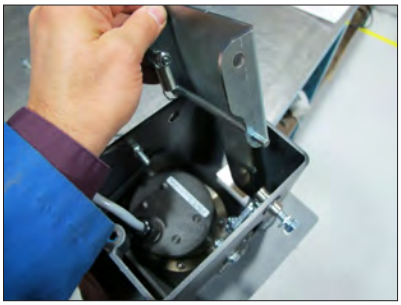
Remove steering wheel assembly (See ***Steering Wheel Assembly*** section directly above).

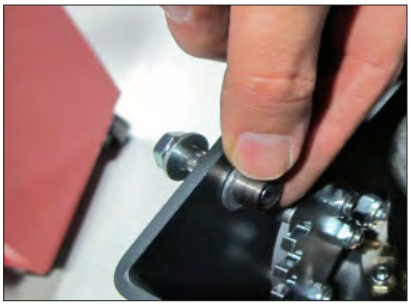
6. Remove steering wheel nut and washer.
7. Remove steering wheel using a three jaw puller. DO NOT hit the shaft with a hammer.

8. Remove retaining nut, spring and spring anchor hardware

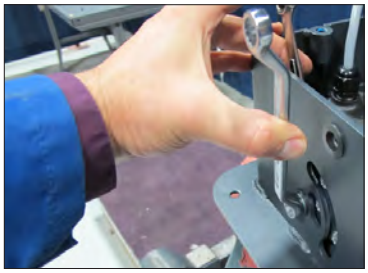
9. Remove tilt lever pivot hardware on one side.

10. Remove tilt lever pivot nut on other side. Remove tilt lever, then remove pivot hardware

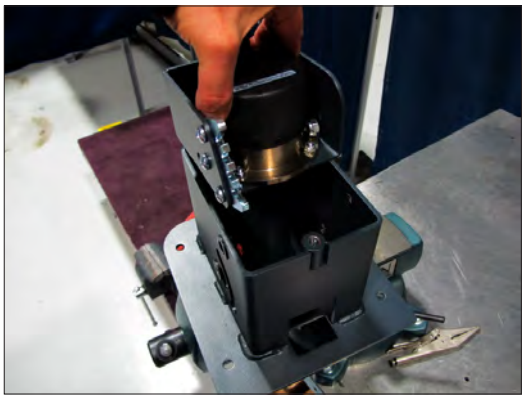




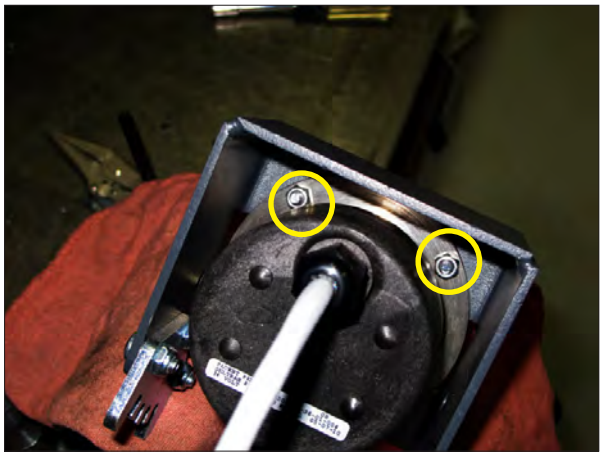
11. Remove steering pivot nut and hardware on one side, then on the other.



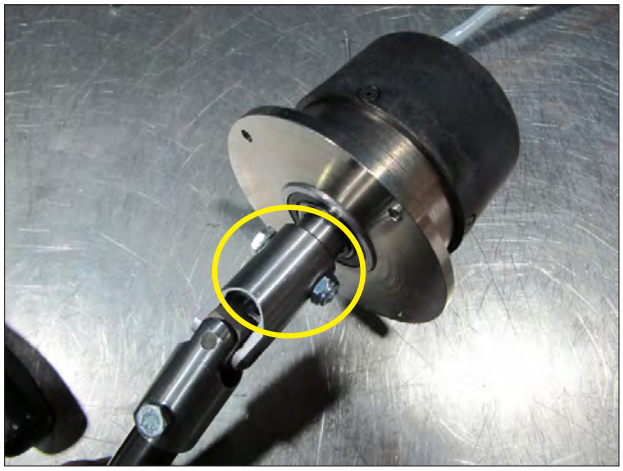
12. Lift tilt steering “column” out of the steering mount “box”.



13. Remove the 4 nuts and screws securing the steering wheel rotation sensor, then remove the sensor and shaft out of the weldment.

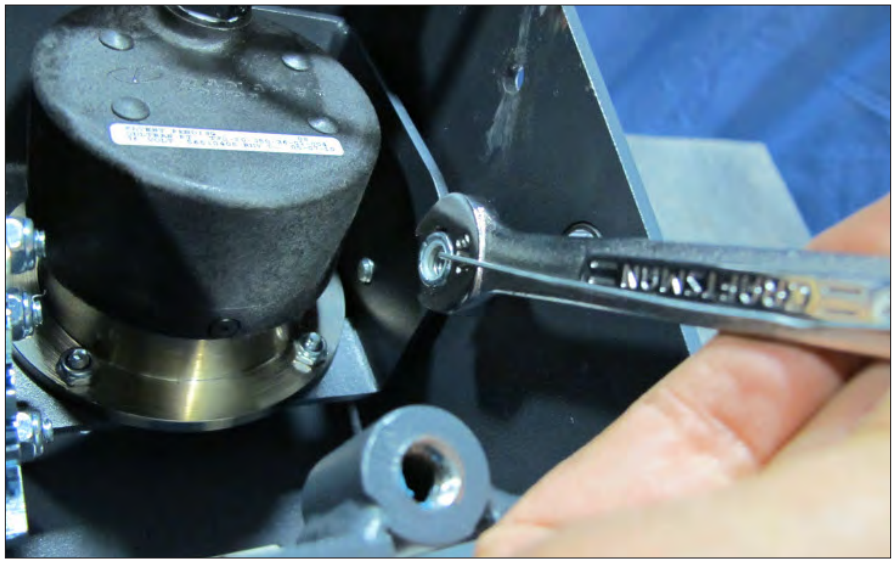


14. Remove the nut and bolt that attaches the universal joint to the sensor shaft.



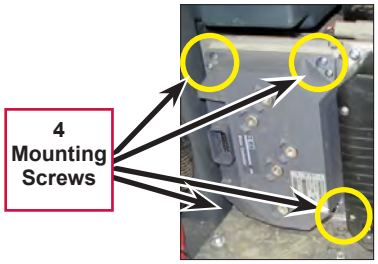
15. Reassemble in the reverse order.

    a. Reassembly tip: When installing the steering pivot hardware, use a short, bent, wire hook along with an open end wrench to position and hold the nut.



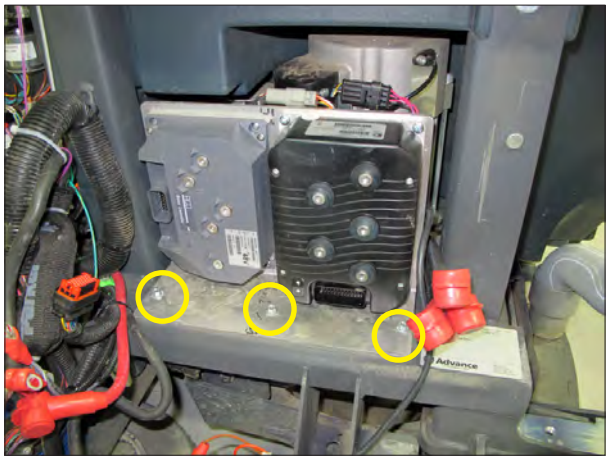
Steering Controller

1. Drain recovery tank.
2. Turn machine off, set the parking brake and disconnect the main power plug.
3. Remove recovery tank
   a. Tip tank out and let it rest on the retention cable.
   b. Disconnect the vacuum motor electrical connector. (If equipped with extended scrub, also disconnect the additional electrical connector and hose connection.)
   c. With a helper, remove the retaining cable clip, tip tank down and remove it.
4. Label controller wiring to make correct reassembly easier, then disconnect all wiring.
5. Remove 4 controller mounting screws.
6. Reassemble in reverse order.



Steering Actuator

1. Drain recovery tank.
2. Turn machine off, set the parking brake and disconnect the main power plug.
3. Remove recovery tank
   a. Tip tank out and let it rest on the retention cable.
   b. Disconnect the vacuum motor electrical connector. (If equipped with extended scrub, also disconnect the additional electrical connector and hose connection.)
   c. With a helper, remove the retaining cable clip, tip tank down and remove it.
4. Disconnect wiring to main machine controller.
5. Label the steering controller wiring and the drive controller wiring to make correct reassembly easier, then disconnect all wiring to both controllers.



6. Remove the three screws securing the controller mounting bracket to the frame, then remove the assembly.

7. Disconnect the steering actuator encoder connector.

8. Remove the four steering actuator mounting bolts.
9. Remove the steering actuator.
10. Reassemble in reverse order.

Specifications

Shop Measurements

Shop measurements are values that were measured on a real machine. While they are not “specifications”, they can help you recognize normal vs. abnormal.

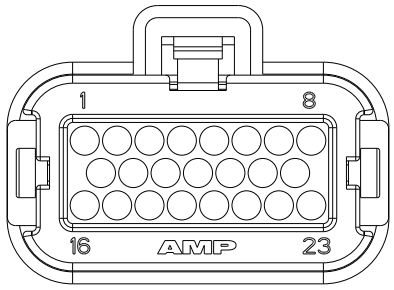
Steering Wheel Rotation Sensor Voltage Measurements

All voltages are DC unless otherwise stated and were measured with the negative (black) voltmeter lead on battery negative and the key on.

Pin #	Wire Color (harness side)	Circuit	Voltage	Condition
1	GRN/WHT	Encoder A1	4.77v 0.09v	Move steering wheel slowly. Voltage switches from low to high.
2	BLU	Encoder A2	4.77v 0.10v	Move steering wheel slowly. Voltage switches from low to high.
3	BLK	Ground	.003v	
4	ORN/BLK	5v supply	5.02v	
5	RED/WHT	Encoder B1	4.77v 0.09v	Move steering wheel slowly. Voltage switches from low to high.
6	GRN/BLK	Encoder B2	4.76v 0.10	Move steering wheel slowly. Voltage switches from low to high.
7	BLK	Ground	0.01v	
8	ORN/BLK	5v supply	5.02v	
9	BRN/WHT	TFD control	23.89v	No noticeable change at soft stop
10	GRA/ORN	TFD supply	37.76v	

Steering Controller Voltage Measurements

J5 Connector



Pin	Wire Color	Circuit	Voltage
J5-1	GRA/ORN	Key Switch Power	38.5
J5-2	BRN/WHT	TFD Control	23.9v
J5-3	ORN/BLK	5v supply - out	5.03
J5-4	BLK	Ground (Internal)	0.002v
J5-5	WHT	Motor Encoder	2.6v (motor stationary) 3.5v (motor moving)
J5-6	BLU/GRA	Motor Encoder	2.6v (motor stationary) 3.5v (motor moving)
J5-7		Not used	
J5-8	BLK	Can bus B-	0.009v
J5-9		Not used	
J5-10	RED/WHT	Steering Wheel Sensor Encoder B1	4.8v or 0.10v (switches high and low as steering wheel is moved slowly)
J5-11	GRN/WHT	Steering Wheel Sensor Encoder A1	4.8v or 0.09v (switches high and low as steering wheel is moved slowly)
J5-12	GRA/ORN	Application Config.	38.34v
J5-13	WHT/BLU	Right Travel Limit Switch	0.002v when not at limit 38.19v when at right limit
J5-14		Not used	
J5-15	GRN	Can Lo	2.45v
J5-16	PINK	Motor Temp Sensor	0.564v at “room” temperature 3.0v with sensor unplugged
J5-17	BLU	Steering Wheel Sensor Encoder A2	4.8v or 0.10v (switches high and low as steering wheel is moved slowly)
J5-18	VIO	Safety Relay Control	38.2v at initial key on 0.015v when relay is energized
J5-19	ORN/RED	Left Travel Limit Switch	0.008v when not at limit 38.2v when at left limit
J5-20	GRN/BLK	Steering Wheel Sensor Encoder B2	4.8v or 0.10v (switches high and low as steering wheel is moved slowly)
J5-21		Not used	
J5-22		Not used	
J5-23	YEL	Can Hi	2.53v

Motor U, V and W Terminal Pair Voltages

- U to V - 1.9 VAC with stationary motor. Up to 18 VAC when motor is turning quickly.
- V to W - 1.9 VAC with stationary motor. Up to 18 VAC when motor is turning quickly.
- W to U - 1.9 VAC with stationary motor. Up to 18 VAC when motor is turning quickly.

Motor U, V and W Terminal Pair Frequency

- U to V -16-20 HZ with stationary motor. Up to 250 HZ when motor is turning quickly.
- V to W - 16-20 HZ with stationary motor. Up to 250 HZ when motor is turning quickly.
- W to U - 16-20 HZ with stationary motor. Up to 250 HZ when motor is turning quickly.

System Current Draw

Measured with amp clamp around battery positive feed to steering controller.

- Approximately 4.5 amps while turning with stationary machine.

Measured at each U, V and W wire

- Approximately 4.5 amps while turning with stationary machine

Steering Contactor

Winding - 118 Ohms

Safety Relay

Winding - 813 Ohms

Special Tools

3 jaw puller for steering wheel removal.

Sweep System, Main

Functional Description

Overview

The main sweep system picks up debris from the floor and throws it into the hopper for later disposal. The main sweep system includes the main broom, broom motor, and the broom lift actuator which lowers and raises the main broom.

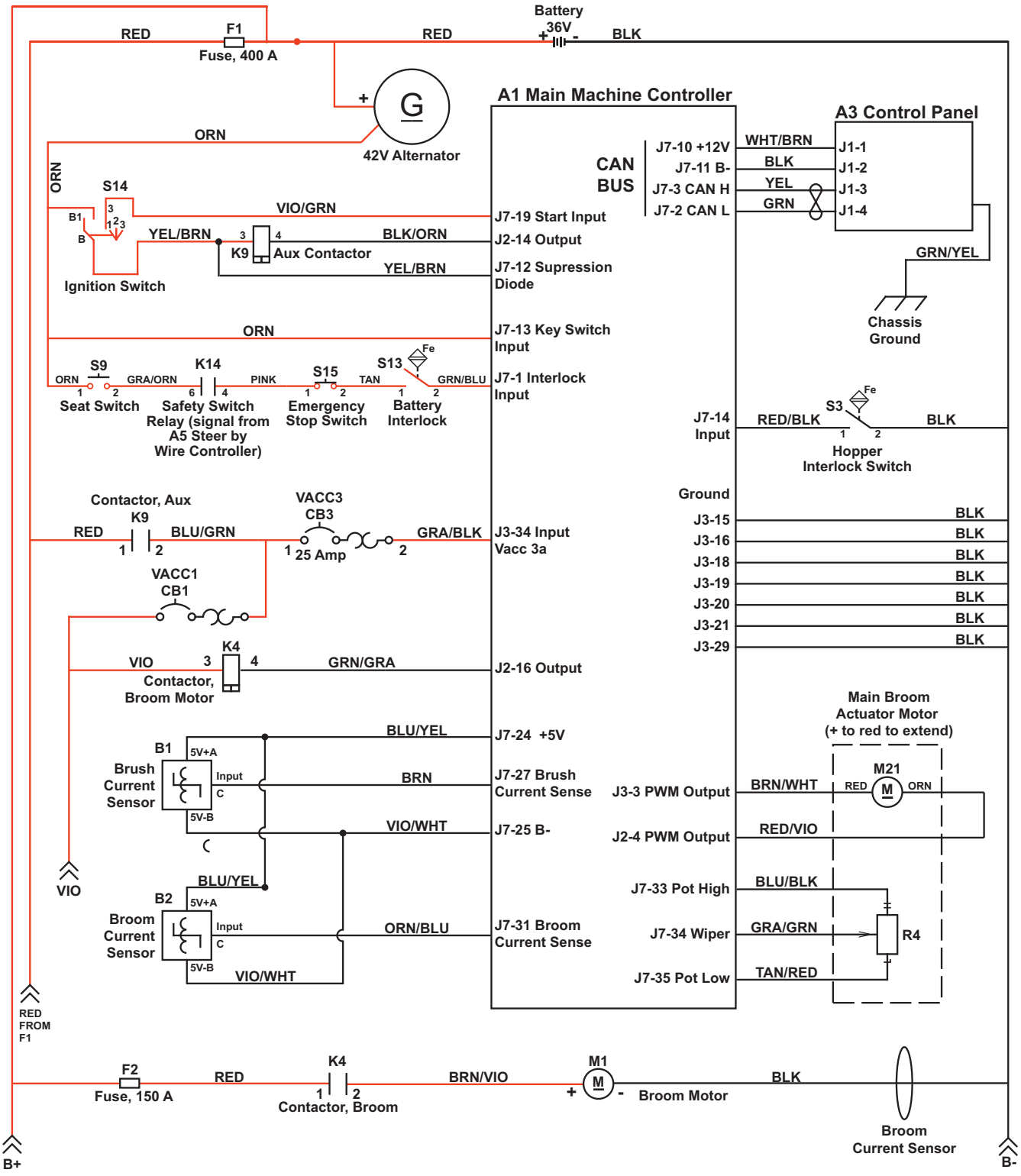
The broom lift actuator lowers the main broom any time the sweep system is enabled. The main broom motor switches on when the drive pedal is moved from the neutral position. The operator can enable the sweep system independent of the scrub system.

The hopper door opens when sweeping to allow the debris to be thrown into the hopper.

A potentiometer in the main broom actuator sends a voltage signal to the A1 Main Machine Controller that varies with the broom height. The A1 Main Machine Controller uses this signal to return the broom to the previous height setting whenever the sweep system is enabled.

The main sweep system has a “float” function in which the main machine controller drives the actuator all the way down so the weight of the main broom is resting on the floor. The linkage is slotted which allows the broom to follow the contour of the floor.

Main Sweep System Wiring Diagram



Circuit Description

The Following Conditions Must be Met for the Main Sweep System To Operate

- The **Hopper Interlock Switch S3** must be closed.
- There must be positive voltage to the **J7-1 Interlock Input**. For this to happen:
  - The **Seat Switch S9** must be closed.
  - The **Safety Relay K14** on the **Steer By Wire Controller A5** must energize the coil to close the **Safety Relay K14** contactor.
  - The **Emergency Stop Switch S15** must be closed.
  - The **Battery Interlock S13** must be closed.
- The **400-amp Fuse F1** must be closed to provide positive voltage from the **Battery** to the load side of **Auxiliary Contactor K9**.
- The **Ignition Switch S14** must be closed to provide positive voltage to the **Auxiliary Contactor K9** coil. The **J2-14 Output** on the **A1 Main Machine Controller** provides ground to the **Auxiliary Contactor K9** coil when the **Ignition Switch S14** provides an input to the **Key Switch Input J7-13**.
- The **Auxiliary Contactor K9** must be closed to provide positive voltage to circuit breaker **VACC1/CB1**.
- Circuit breaker **VACC1/CB1** must be closed to provide positive voltage to the **Broom Motor Contactor K4**.
- The **J2-16 Output** on the **A1 Main Machine Controller** must provide a ground to the **Broom Motor Contactor K4** coil. **J2-16** provides ground to **K4** under the following conditions:
  - The **A1 Main Machine Controller** must receive a signal from the **A3 Control Panel** via the **CAN BUS** that the operator has pressed the sweep switch.
  - The **A1 Main Machine Controller** must receive a signal from the **A2 Drive Controller** via the **CAN BUS** that the machine is moving forward or reverse.
- The **150-amp Fuse F2** must be closed to provide positive voltage from the **Battery** to the load side of the **Broom Motor Contactor K4**,
- The **Broom Motor M1** must have connections to battery ground **B-**.

Main Broom Actuator Motor

The **J3-3** and **J2-4 PWM Outputs** from the A1 Main Machine Controller provide voltage to the **Main Broom Actuator Motor M21**. The output polarity determines whether the **Main Broom Actuator Motor** lowers or raises the scrub deck.

The resistance through the main broom actuator potentiometer **R4** varies with the broom height. The **J7-33 POT HIGH** pin sends a fixed positive voltage to **R4** with **J7-35 POT LOW** as a ground. The A1 Main Machine Controller reads the voltage through **R4** from **J7-34 WIPER** to determine the broom height.

Broom Current Sensor

- **J7-24** provides +5 volts to the **Broom Current Sensor**.
- **J7-25** provides battery ground (**B-**) to the **Broom Current Sensor**.
- The Input from the **Broom Current Sensor** provides the **Broom Current Sense** signal to **J7-31** on the A1 main machine controller. The A1 main machine controller monitors the current value to set a fault code and shut down the motor if too much current is being used.

Component Locations

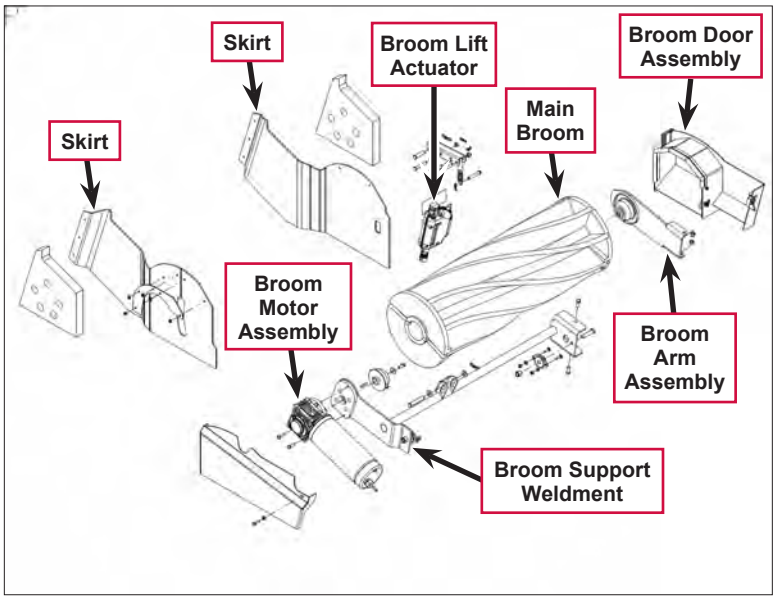
Main Broom and Drive Components

The **Main Broom** is supported by the **Broom Arm Assembly** and the **Broom Support Weldment**. The **Broom Motor Assembly** drives the **Main Broom** and is mounted to the **Broom Support Weldment**.

The **Broom Lift Actuator** raises and lowers the **Broom Support Weldment** which pivots on the machine frame to raise and lower the attached **Main Broom**.

The **Broom Door Assembly** swings out of the way to allow access to the **Broom Arm Assembly**. The **Broom Arm Assembly** is hinged to allow the **Main Broom** to be removed from the machine for maintenance or replacement.

The left and right **Skirts** direct the debris swept by the **Main Broom** into the hopper.

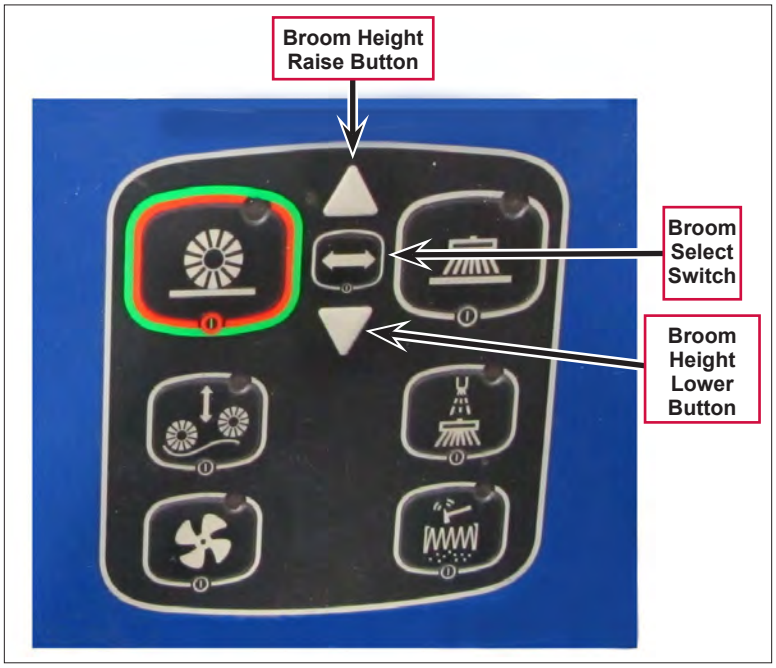


Maintenance and Adjustments

Warning! ***Before performing any maintenance or adjustments on the main sweep system, make sure the key switch is off, the key is removed from the machine and the parking brake is engaged.***

To Adjust the Main Broom Height

1. Turn the key switch on, then press the **Broom Select Switch** twice to select the main broom. The main broom motor will start and the actuator will lower the broom to its preset height. After running for a short time, the broom motor will shut off and the actuator will raise the broom to its upper position.

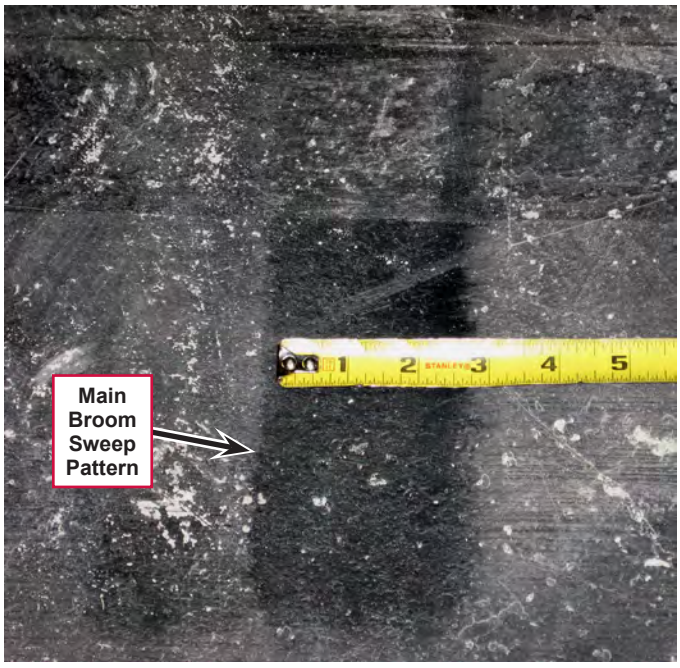


2. Check the **Main Broom Sweep Pattern** on the floor. The **Pattern** should be 2” to 3” (50-75 mm)wide, and consistent in width along the entire length of the main broom.

3. To adjust the width of the **Main Broom Sweep Pattern**, switch on and lower the main broom as described in step 1. While the main broom motor is running, press the **Broom Height Raise Button** or **Broom Height Lower Button** to adjust the broom height. Note that:

   - Raising the main broom will narrow the **Main Broom Sweep Pattern**.
   - Lowering the main broom will widen the **Main Broom Sweep Pattern**.

4. Allow the broom motor to stop and the broom to retract upward. The machine controller will “remember” the new main broom height and will return the broom to this position when the sweep system is enabled.



Note: *If the width of the main broom sweep pattern is not consistent along the entire length of the main broom, you may need to adjust the main broom tilt. Refer to the* ***To Adjust the Main Broom Tilt*** *section below.*

To Adjust the Main Broom Tilt

1. Loosen the two **1/4”-20 Nyloc® Nuts** holding the **Bearing** on which the **Broom Support Weldment** pivots on the right side. Note that the **1/4”-20 Nyloc® Nuts** and **Bearing** are accessed from the inside of the main broom compartment and are located behind the **1/2”-13 Screw** just to the rear of the **Broom Arm Assembly**. Also note that the **Bearing** and mounting screws ride in slotted holes in the supporting weldment to allow for up/down adjustment.

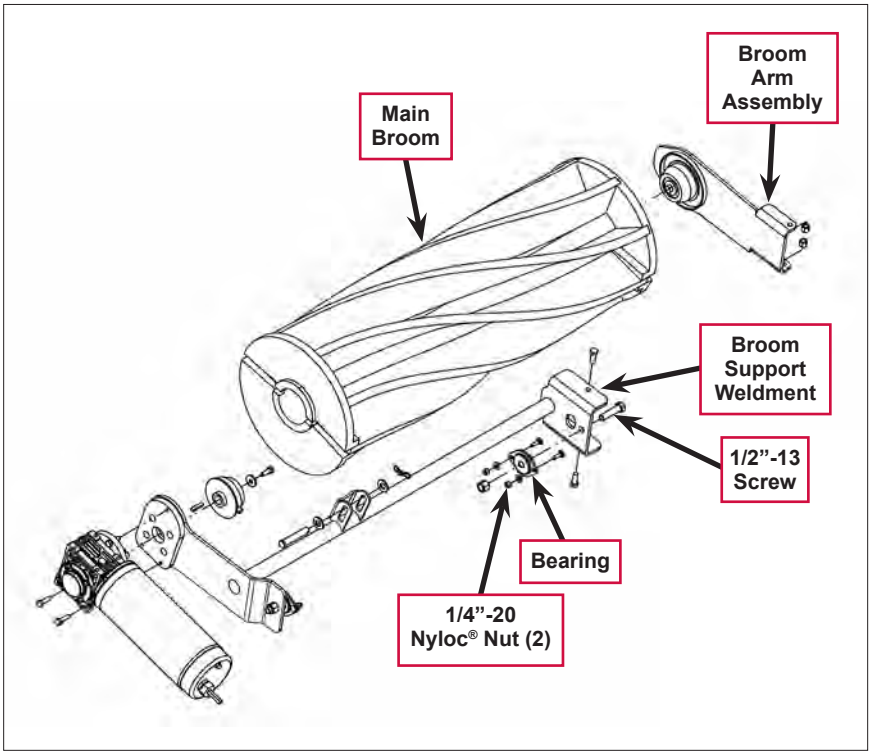
2. Move the **Bearing** and attached **Broom Support Weldment** up or down as necessary so the width of the main broom sweep pattern is consistent along the entire length of the main broom. Note that:

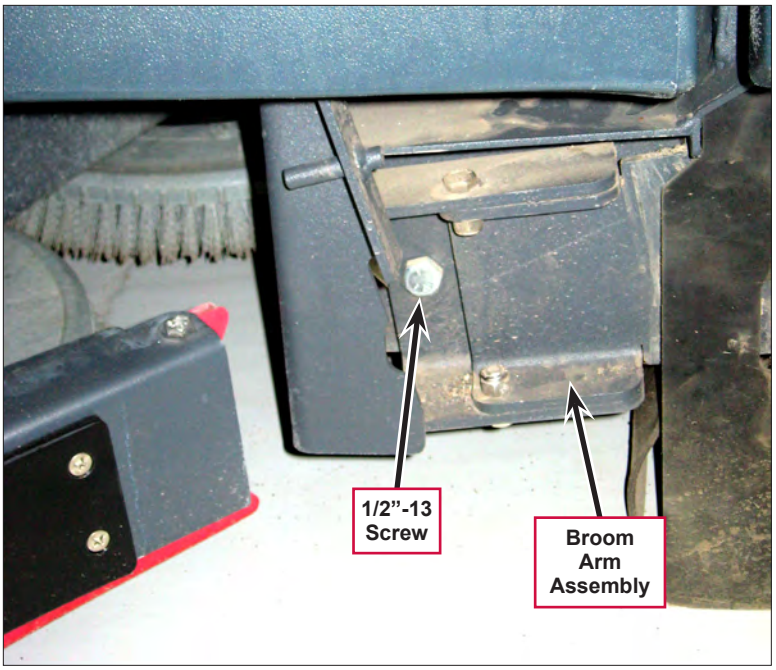
   - *Raising* the right side of the main broom will *narrow* the sweep pattern on the right side.
   - *Lowering* the right side of the main broom will *widen* the sweep pattern on the right side.

3. Tighten the two **1/4”-20 Nyloc® Nuts**.

4. Check the main broom sweep pattern.

5. Readjust the main broom tilt as necessary.

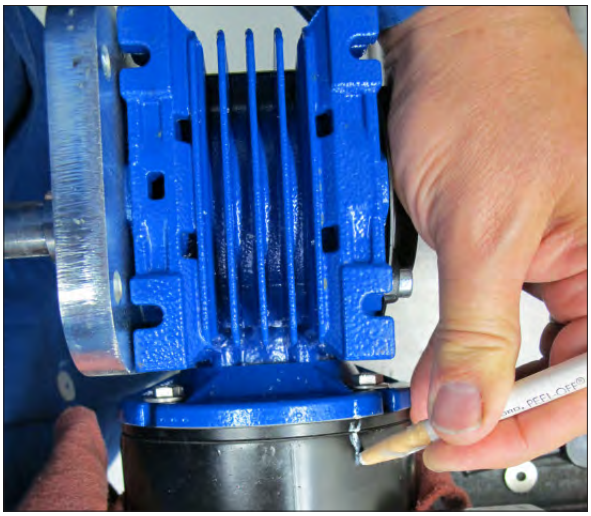




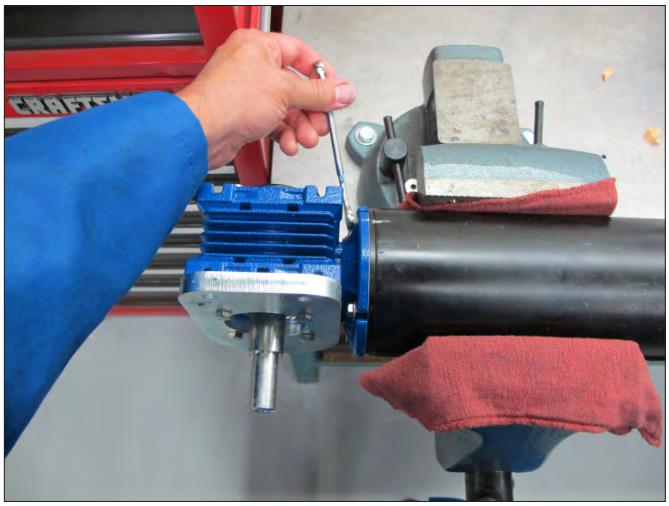
Inspecting/Replacing Main Broom Motor Carbon Brushes

1. Remove the main broom motor and gearbox assembly. See the ***Removal and Installation*** section.

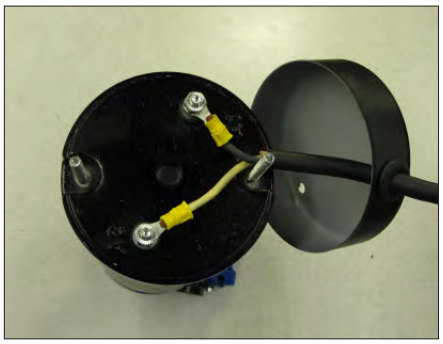
2. Create witness marks on the gearbox, motor end bells (covers) and the motor casing for reassembly.



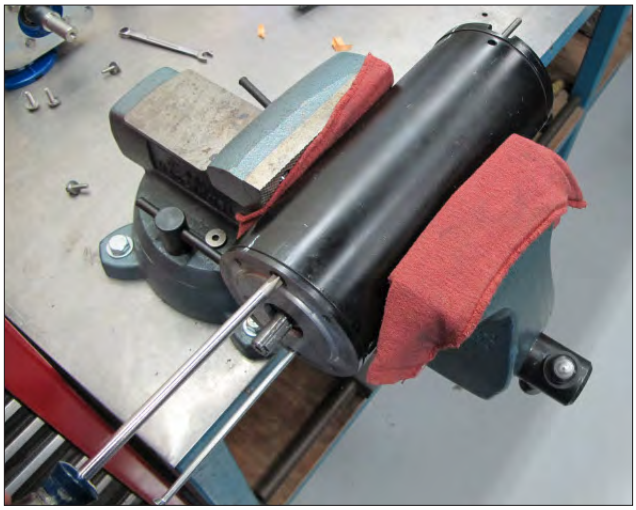
3. Remove the gearbox from the motor.



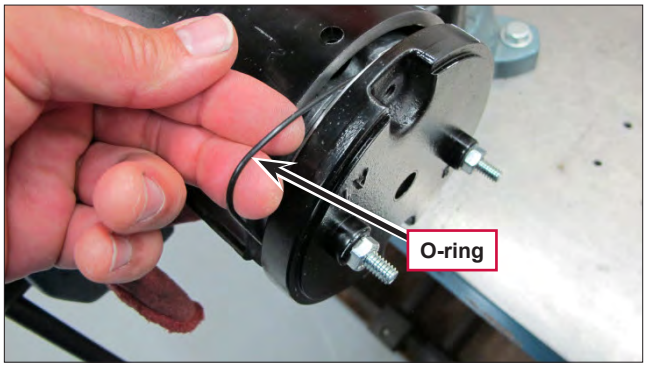
4. Remove the electrical connection cover. Remove the wires from the electrical connections. Note the locations of the wires for reassembly.



5. Working from the gearbox end of the motor, remove the two long through bolts.

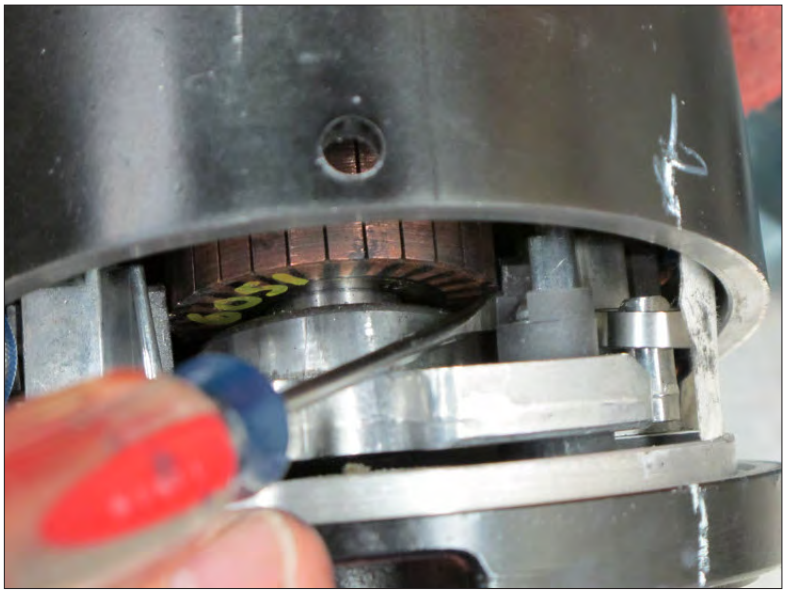


6. Pry off the end bell (cover) at the end opposite the gear box. Take care not to loose the rubber O-ring seal or the wave washer.

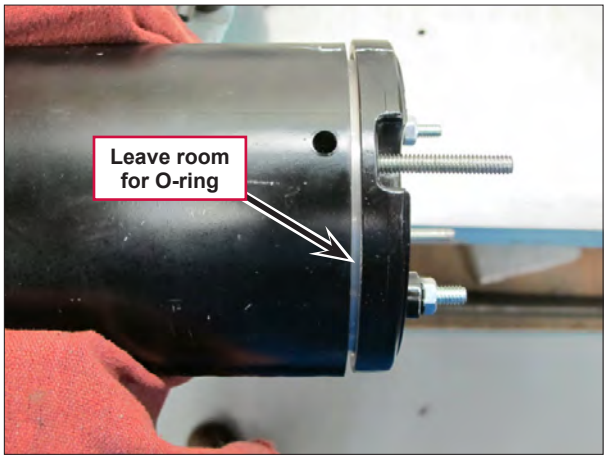


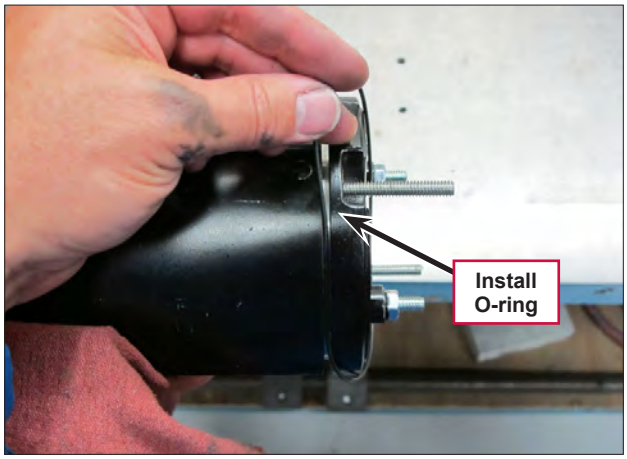
7. Inspect the carbon brushes and replace as necessary. New brush length is approximately 7/8” (22 mm)

8. Temporarily set the O-ring seal aside.
9. Install the wave washer. (Retain it with some grease if necessary)
10. Reinstall the cover.
    a. Gently pry the carbon brushes back against their springs just far enough to slip them over the commutator.



    b. Gently slide the cover into place and align the witness marks made earlier.
11. Reinstall the through bolts and tighten them until the end covers are nearly seated, leaving enough room to install the O-ring seal. Install the O-ring and then tighten the through bolts.





12. Reconnect the wiring and attach the wire cover.
13. Reinstall the gearbox making sure to align the witness marks. The weep hole must be facing the floor when the assembly is installed on the machine.

Troubleshooting

Note: *You can use the Service Mode to toggle the various system components on and off to check for function. Refer to the* ***Control System/Service Mode*** *section for information on how to enter and use the Service Mode.*

Problem	Cause	Correction
The main sweep system is not operating correctly.	An interlock is not closed.	Before you start troubleshooting a specific system, check to make sure: • The emergency stop switch (**S15**) on the Operator control panel is disengaged (rotate clockwise). • The safety relay from the steering system (**K14**) is closed. • The seat switch (**S9**) is closed. • The battery interlock proximity sensor (**S13**) is closed. • The A1 Main Machine Controller is receiving the appropriate signal from the A3 Control Panel via the CAN BUS.
The main broom motor will not run.	The 150-amp Fuse (**F2**) is blown.	Check the Fuse (**F2**) and replace if necessary.
	The hopper is overfilled or is “lip loaded”.	Check for a fault code 54 - Main Broom Motor Overload. If you see fault code 54, empty the hopper.
	There is no voltage to the **K4** contactor coil.	1. Check circuit breakers **CB1** and **CB3** and reset if necessary. 2. Check the **K9** contactor coil resistance. If the coil resistance is not 118 ohms ± 10%, replace the contactor. 3. Check the continuity through contactor **K9** with the coil energized. If the contacts are open, replace the contactor. 4. Check the **J2-16** output from A1 Main Machine Controller.
	There is no positive voltage to the broom motor.	1. Check the wiring and connectors from the load side of contactor **K4** to the broom motor and repair as necessary. 2. Check the **K4** contactor coil resistance. If the coil resistance is not 118 ohms ± 10%, replace the contactor. 3. Check the continuity through contactor **K4** with the coil energized. If the contacts are open, replace the contactor.
	There is no ground connection to the broom motor.	Check the wiring and connectors from the broom motor to battery ground repair as necessary.

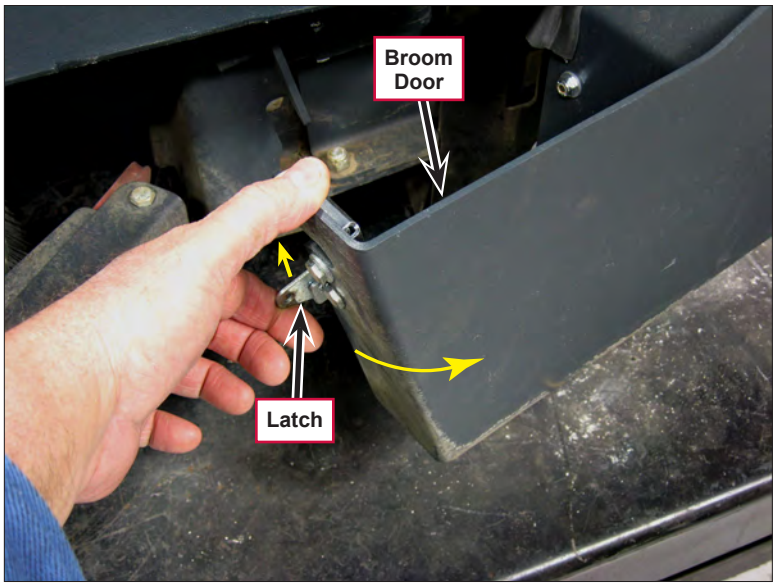
Problem	Cause	Correction
The broom lift actuator is not raising and lowering the main broom.	No voltage to the main broom actuator.	1. Check the wiring and connectors from the A1 Main Machine Controller to the main broom actuator motor and repair as necessary. 2. Check the operation of the broom lift actuator motor (**M21**). If the motor doesn't operate correctly, replace the broom lift actuator. 3. Check the voltage outputs from **J3-3** and **J2-4** on the A1 Main Machine Controller.
The main broom is not moving to the previous position when the sweep system is enabled.	The potentiometer **R4** in the broom lift actuator is not operating correctly.	1. Check the voltage output from **J7-34** to ground as the broom lift actuator raises and lowers the broom. The voltage should vary from 0 (full up position) to approximately 3.3 VDC (full down position). 2. If the voltages are not in the 0 to 3.3 volt range, replace the broom lift actuator.
	There is no voltage from the A1 Main Machine Controller to potentiometer **R4**.	Check the output from **J7-33** on the A1 Main Machine Controller.

Removal and Installation

Warning! Before removing or reinstalling any machine components, make sure the key switch is off, the key is removed from the machine and the parking brake is engaged.

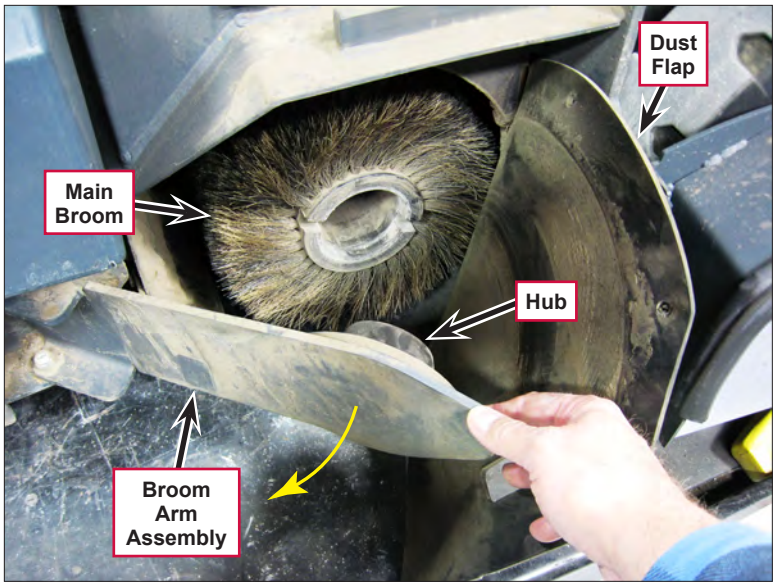
To Remove the Main Broom

1. Make sure the main broom is in the raised position.
2. Lift up the **Latch** and swing open the **Broom Door**.



3. Move the **Dust Flap** out of the way and swing open the **Broom Arm Assembly**.

4. Pull the **Main Broom** out of the machine.



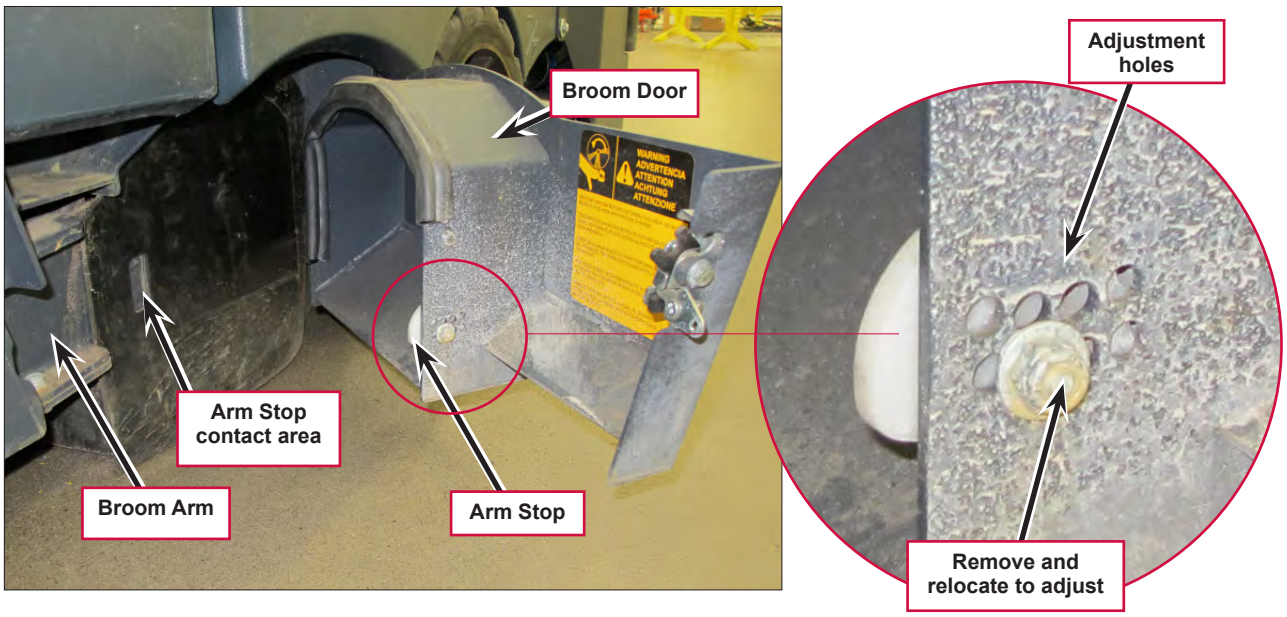
To Install the Main Broom

1. Install the **Main Broom** into the machine. Rotate the **Main Broom** as necessary to make sure the broom lugs on the far side engage the drive hub on the broom motor.

2. Close the **Broom Arm Assembly**, making sure the **Main Broom** engages the **Hub** on the **Broom Arm Assembly**.

3. Move the **Dust Flap** back into position, then close and latch the **Broom Door**

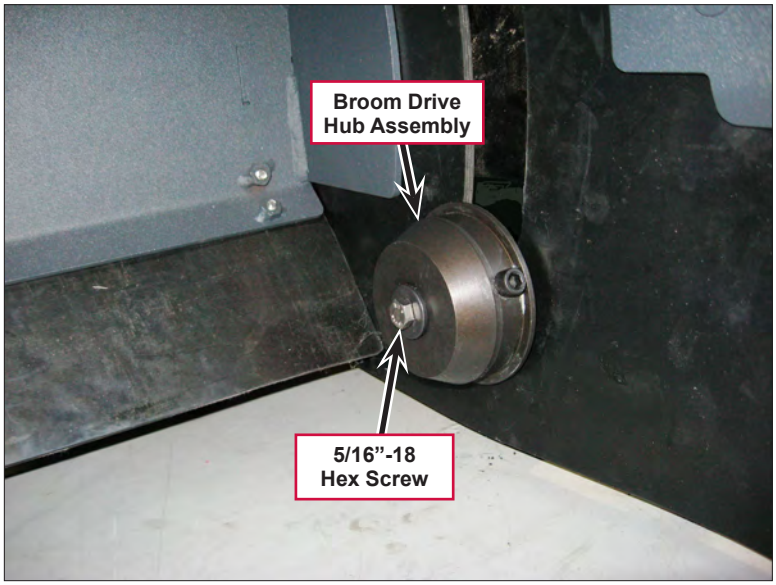
4. Check and adjust the broom Arm Stop on the Broom Door as necessary. The Arm Stop should be adjusted to prevent the Broom Arm from moving outward while still allowing the door to latch easily.



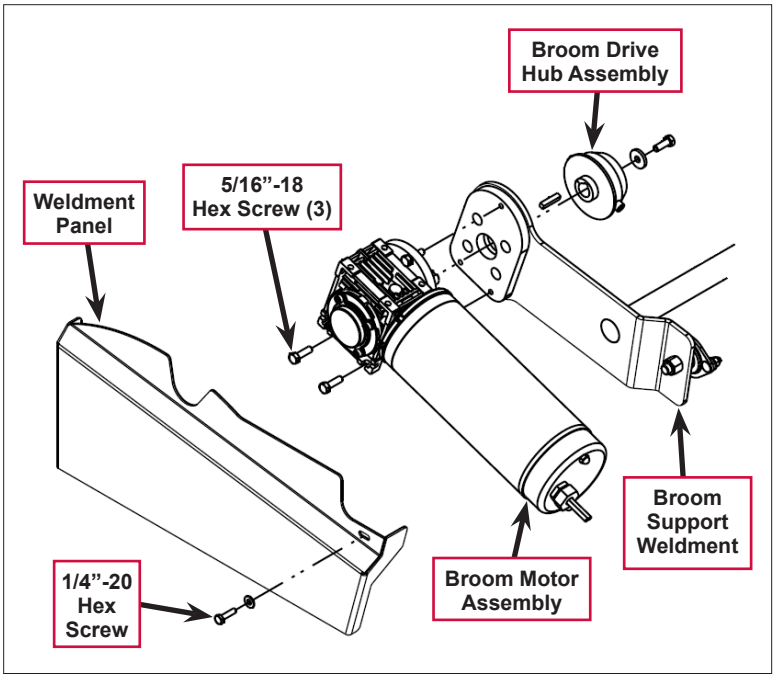
Note: *Make sure you adjust the main broom height when installing a new broom. Failure to do so will reduce the life of the broom and may lead to setting a code 54 (main broom overload) which will shut down the main broom.*

To Remove and Reinstall the Broom Motor Assembly

1. Remove the main broom from the machine.
2. Open the hopper and engage the prop rod.
3. Remove the **5/16”-18 Hex Screw** holding the **Broom Drive Hub Assembly** onto the gearbox shaft, then remove the **Broom Drive Hub Assembly**,washer and key.



4. Remove the **1/4”-20 Hex Screw** and washer holding the **Weldment Panel** to the machine frame. Note that the front edge of the **Weldment Panel** is pinned to the frame.
5. Disconnect the broom motor electrical connector from the wiring harness.
6. Remove the three **5/16”-18 Hex Screws** holding the **Broom Motor Assembly** to the **Broom Support Weldment** and remove the **Broom Motor Assembly** from the machine.
7. Reinstall the **Broom Motor Assembly** following the above steps in reverse order.

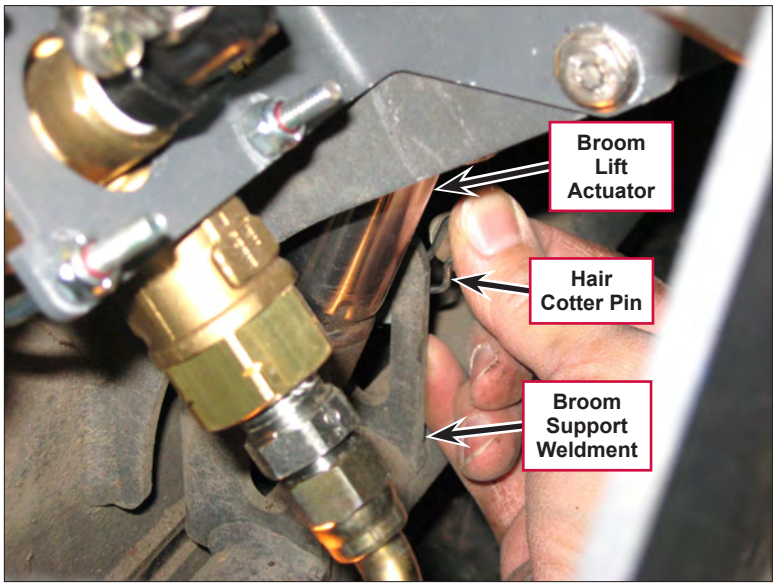


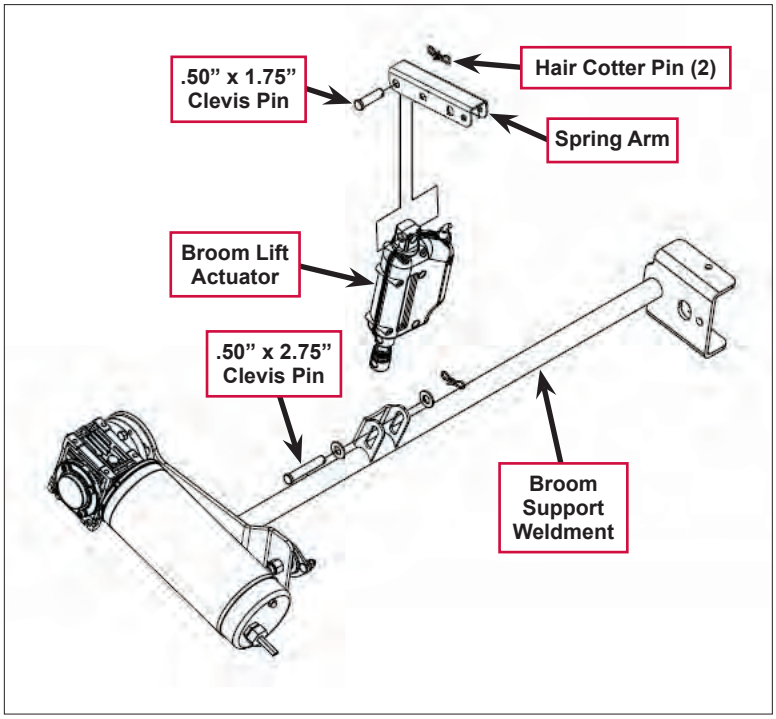
Service Note: *Apply Never-Seez® or an equivalent anti-seize compound on the gearbox shaft when you reinstall the* ***Broom Drive Hub Assembly****.*

Apply Loctite® 242 (blue) on the ***5/16”-18 Hex Screws*** *when reinstalling the* ***Broom Drive Hub Assembly*** *and* ***Broom Motor Assembly.***

To Remove and Reinstall the Broom Lift Actuator

1. Remove the recovery tank.
2. Remove the main broom from the machine.
3. Turn the key switch on and switch the machine to the Service Mode.
4. Extend the scrub deck downward in the Service Test Mode. This will give you additional clearance for removing the hair cotter pins and clevis pins on the broom lift actuator.
5. Extend the main broom downward in the Service Test Mode so the bristles rest on the floor. This will minimize the weight on the broom lift actuator.
6. Remove the **Hair Cotter Pin**, washers and **.50" x 2.75" Clevis Pin** holding the bottom of the **Broom Lift Actuator** to the **Broom Support Weldment**.



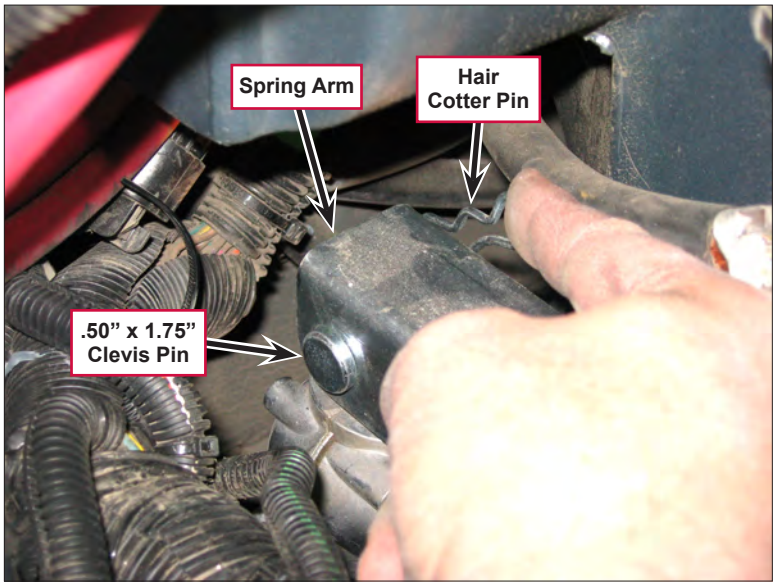


7. Remove the **Hair Cotter Pin**, washers and **.50" x 1.75" Clevis Pin** holding the top of the **Broom Lift Actuator** to the **Spring Arm**.

8. Disconnect the **Broom Lift Actuator** electrical connector and remove the **Broom Lift Actuator** from the machine.

9. Reinstall the **Broom Lift Actuator** by following the above steps in reverse order.

10. Check the main broom height and main broom sweep pattern and adjust as necessary. (Refer to the ***To Adjust the Main Broom Height*** section.)



Specifications

Component	Specifications
Main Broom Motor	RPM - 3400
	Voltage - 36 VDC
	Amperage - 26 Amps
Main Broom Actuator	Dynamic Load - 400 lbs. maximum
	Static Load - 1000 lbs. maximum
	Restraining Torque - Actuator is internally restrained
	Input Voltage - 30 to 40 VDC
	Amperage - 4 Amps at rated dynamic load
	Overload Protection - Ball detent clutch with load rating between 450 and 700 lbs.
	Thermal Protection - Automatic resetting thermal breaker enclosed in motor housing.
	Wiring Polarity: • To extend actuator, connect red lead to positive and yellow lead to negative. • To retract actuator, connect yellow lead to positive and red lead to negative.

Sweep System, Side Broom

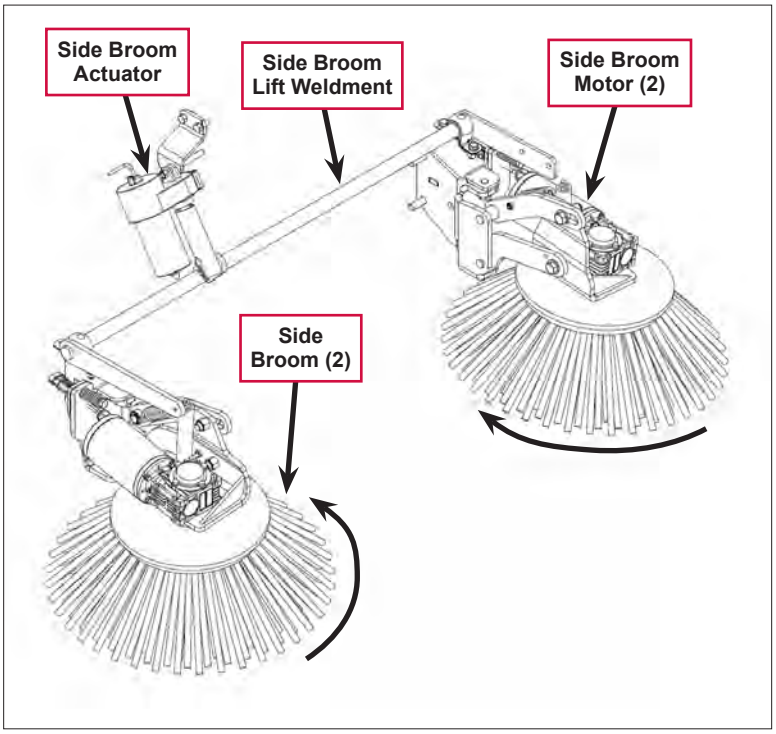
Functional Description

Overview

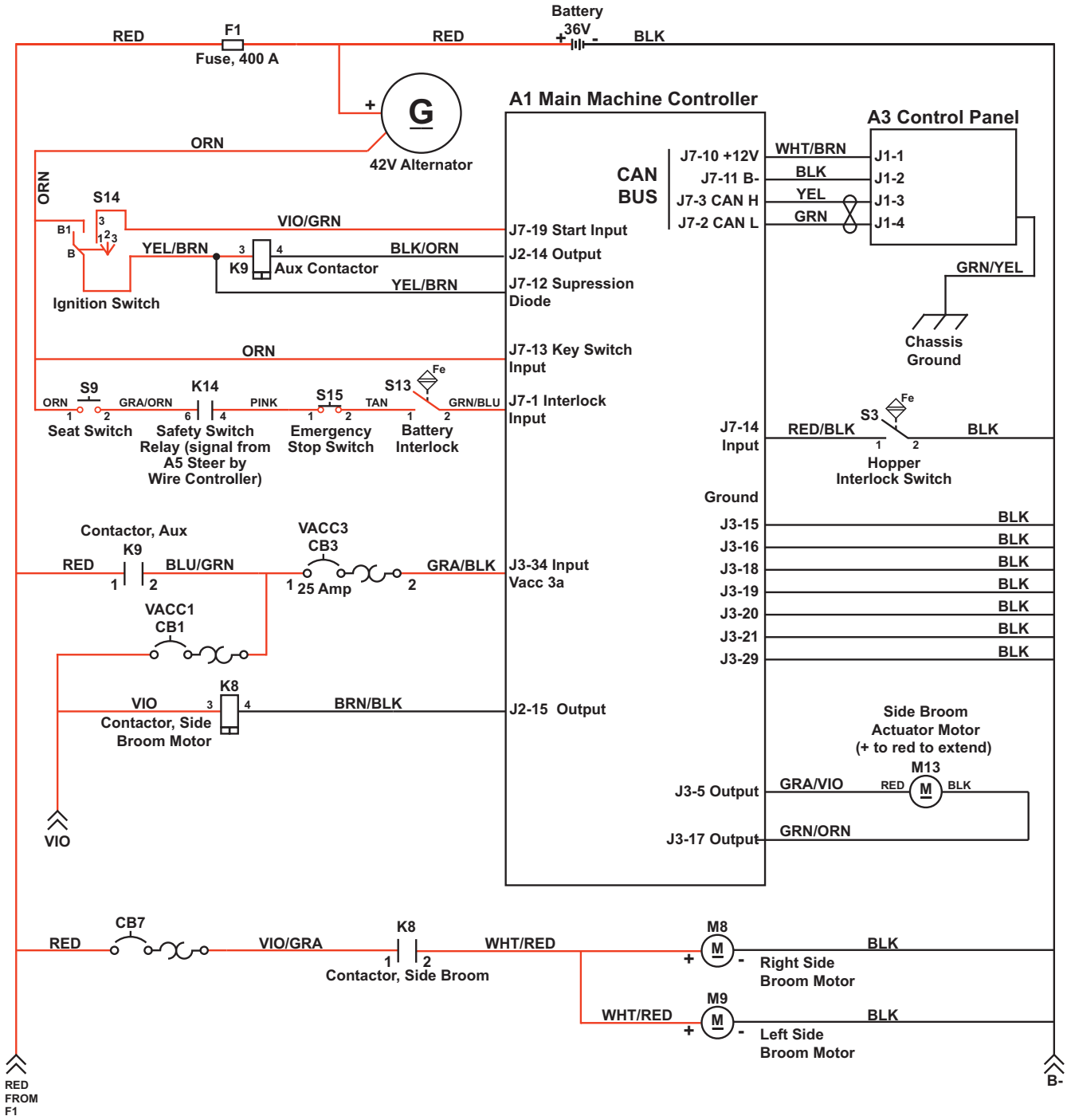
The **Side Brooms** run in opposite directions to direct debris from the sides of the machine toward the center where the main broom can direct it into the hopper.

The side broom sweep system includes the **Side Brooms**, **Side Broom Motors**, and the **Side Broom Actuator** which lowers and raises the **Side Brooms** via linkages connected to the **Side Broom LIft Weldment**.

The **Side Broom Actuator** lowers the **Side Brooms** any time the sweep system is enabled. The **Side Broom Motors** switch on when the drive pedal is moved from the neutral position. The operator can enable and disable the **Side Brooms** independent of the main sweep system.



Side Broom System Wiring Diagram



Circuit Description

The Following Conditions Must be Met for the Side Broom Sweep System To Operate

- The **Hopper Interlock Switch S3** must be closed.
- There must be positive voltage to the **J7-1 Interlock Input**. For this to happen:
  - The **Seat Switch S9** must be closed.
  - The **Safety Relay K14** on the **Steer By Wire Controller A5** must energize the coil to close the **Safety Relay K14** contactor.
  - The **Emergency Stop Switch S15** must be closed.
  - The **Battery Interlock S13** must be closed.
- The **400-amp Fuse F1** must be closed to provide positive voltage from the **Battery** to the load side of **Auxiliary Contactor K9** and circuit breaker **CB7**.
- The **Ignition Switch S14** must be closed to provide positive voltage to the **Auxiliary Contactor K9** coil. The **J2-14 Output** on the **A1 Main Machine Controller** provides ground to the **Auxiliary Contactor K9** coil when the **Ignition Switch S14** provides an input to the **Key Switch Input J7-13**.
- The **Auxiliary Contactor K9** must be closed to provide positive voltage to circuit breaker **VACC1/CB1**.
- Circuit breaker **VACC1/CB1** must be closed to provide positive voltage to the **Side Broom Motor Contactor K8** coil.
- The **J2-15 Output** on the **A1 Main Machine Controller** must provide a ground to the **Side Broom Motor Contactor K8** coil. **J2-15** provides ground to **K8** under the following conditions:
  - The **A1 Main Machine Controller** must receive a signal from the **A3 Control Panel** via the **CAN BUS** that the operator has pressed the sweep and side broom switches.
  - The **A1 Main Machine Controller** must receive a signal from the **A2 Drive Controller** via the **CAN BUS** that the machine is moving forward or reverse.
- Circuit breaker **CB7** must be closed to provide positive voltage to the load side of **Side Broom Motor Contactor K8**.
- **Side Broom Motor Contactor K8** must be closed to provide positive voltage to the **Side Broom Motors M8** and **M9**.
- The **Side Broom Motors M8** and **M9** must have connections to battery ground **B-**.

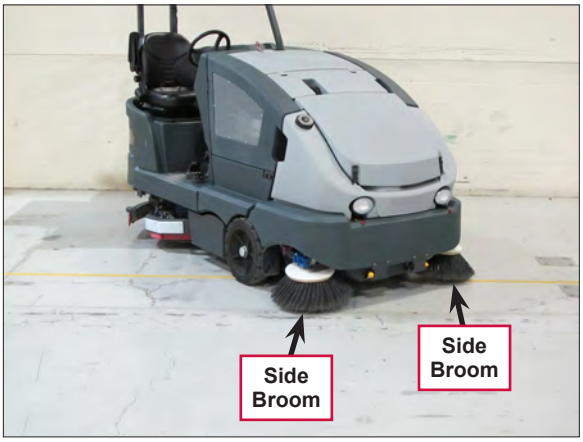
Side Broom Actuator Motor

The **J3-5** and **J3-17 Outputs** from the **A1 Main Machine Controller** provide voltage to the **Side Broom Actuator Motor M13**. The output polarity determines whether the **Side Broom Actuator Motor** lowers or raises the side brooms.

Component Locations

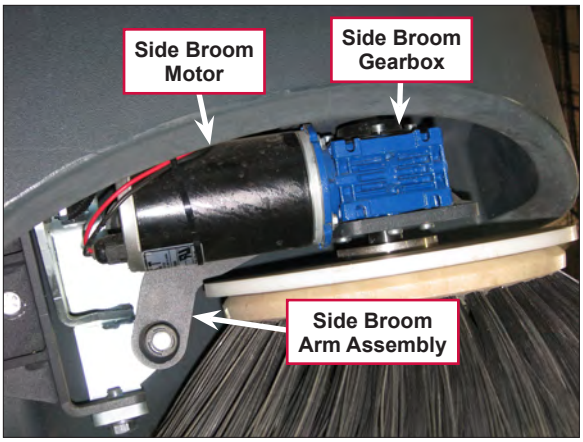
Side Brooms

The **Side Brooms** are mounted on the front corners of the machine, below the hopper.



Side Broom Motor Assemblies

The side broom motor assemblies consist of the **Side Broom Motors** and **Side Broom Gearbox**. The **Side Broom Motor Assemblies** are mounted on **Side Broom Arm Assemblies** connected to the side broom lift weldment.



Side Broom Actuator

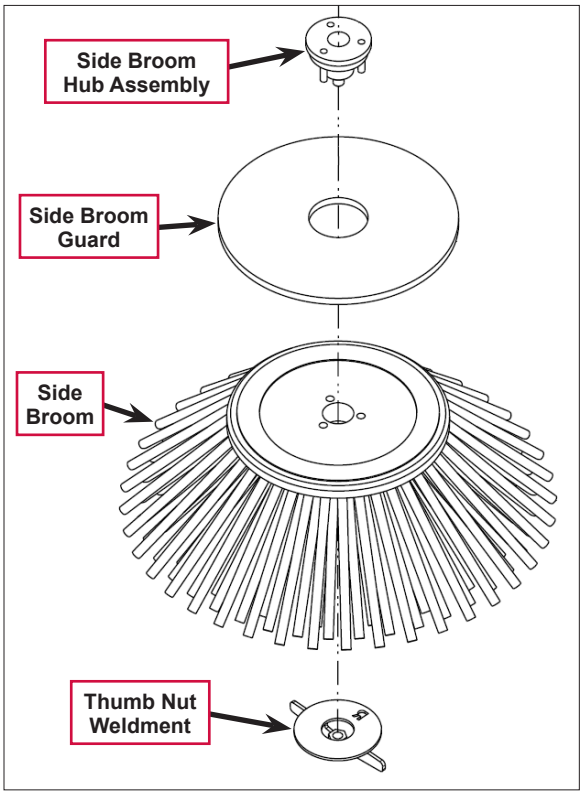
The **Side Broom Actuator** is on the upper hopper and lowers and raises the side broom lift weldment and attached side broom motor assemblies.

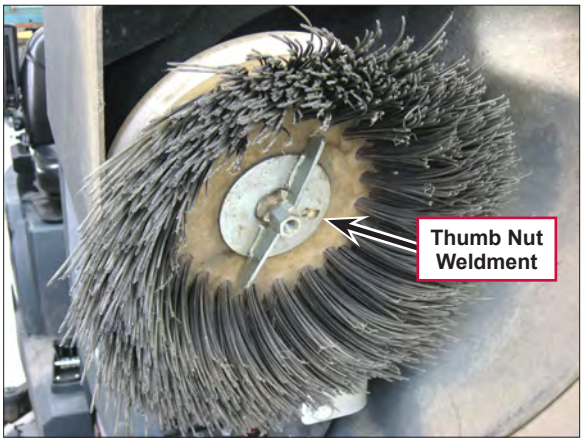
Maintenance and Adjustments

Warning! ***Before performing any maintenance or adjustments on the side sweep system, make sure the key switch is off, the key is removed from the machine and the parking brake is engaged.***

To Remove and Reinstall a Side Broom

1. Turn the key switch on, raise the hopper to convenient height, then turn the key switch off.
2. Remove the key from the machine.
3. Unscrew the **Thumb Nut Weldment**, then remove the **Side Broom** and **Side Broom Guard** from the **Side Broom Hub Assembly**.
4. Reinstall the **Side Broom** by following the above steps in reverse order.



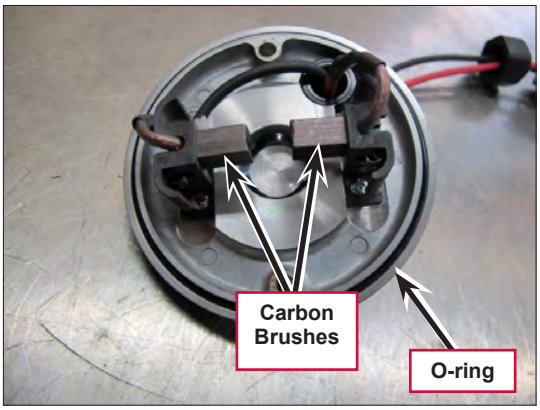


Inspecting/Replacing Side Broom Motor Carbon Brushes

1. Remove the side broom motor and gearbox assembly. See the ***Removal and Installation*** section.
2. Create witness marks on the gearbox, motor end bells (covers) and the motor casing for reassembly.

3. Loosen the wire retaining nut and remove the two through bolts. Do not lose or damage the rubber washers.

4. Remove the end cover. Do not lose or damage the O-ring seal.



5. Inspect the carbon brushes and replace as necessary. New brush length is approximately 13/16” (20 mm)

6. Reinstall the cover with O-ring in place.

   a. Gently pry the carbon brushes back against their springs just far enough to slip them over the commutator.

   b. Gently slide the cover into place and align the witness marks made earlier.

7. Reinstall the through bolts and tighten the wire retaining nut.

Troubleshooting

Note: *You can use the Service Mode to toggle the various system components on and off to check for function. Refer to the* ***Control System/Service Mode*** *section for information on how to enter and use the Service Mode.*

Problem	Cause	Correction
The side sweep system is not operating correctly.	An interlock is not closed.	Before you start troubleshooting a specific system, check to make sure: • The emergency stop switch (**S15**) on the Operator control panel is disengaged (rotate clockwise). • The safety relay from the steering system (**K14**) is closed. • The seat switch (**S9**) is closed. • The battery interlock proximity sensor (**S13**) is closed. • The A1 Main Machine Controller is receiving the appropriate signal from the A3 Control Panel via the CAN BUS.
The side broom motors will not run.	The 400-amp Fuse (**F1**) is blown.	Check the Fuse (**F1**) and replace if necessary.
	Circuit breaker **CB7** is open.	Reset circuit breaker **CB7**.
	There is no voltage to the **K8** contactor coil.	1. Check circuit breakers **CB1** and **CB3** and reset if necessary. 2. Check the **K9** contactor coil resistance. If the coil resistance is not 118 ohms ± 10%, replace the contactor. 3. Check the continuity through contactor **K9** with the coil energized. If the contacts are open, replace the contactor. 4. Check the **J2-15** output from A1 Main Machine Controller.
	There is no positive voltage to the side broom motors.	1. Check the wiring and connectors from the load side of contactor **K8** to the side broom motors and repair as necessary. 2. Check the **K8** contactor coil resistance. If the coil resistance is not 118 ohms ± 10%, replace the contactor. 3. Check the continuity through contactor **K8** with the coil energized. If the contacts are open, replace the contactor.
	There is no ground connection to the side broom motors.	Check the wiring and connectors from the side broom motors to battery ground repair as necessary.

Problem	Cause	Correction
The side broom actuator is not raising and lowering the side brooms.	No voltage to the side broom actuator.	1. Check the wiring and connectors from the A1 Main Machine Controller to the side broom actuator and repair as necessary. 2. Check the voltage outputs from **J3-5** and **J3-17** on the A1 Main Machine Controller.
	The side broom actuator is not working.	Check the operation of the side lift actuator motor (**M13**). If the motor doesn't operate, replace the side broom actuator.

Removal and Installation

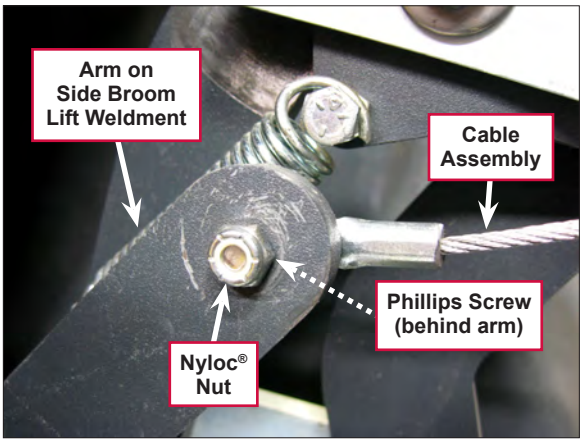
Warning! Before removing or reinstalling any machine components, make sure the key switch is off, the key is removed from the machine and the parking brake is engaged.

To Remove and Reinstall a Side Broom Motor Assembly

1. Dump the hopper.
2. Make sure the parking brake is engaged.
3. Turn the key switch on and switch the machine to the Service Mode.
4. Raise the hopper so the side brooms are at a convenient working height, then support the hopper with jack stands or other suitable supports.

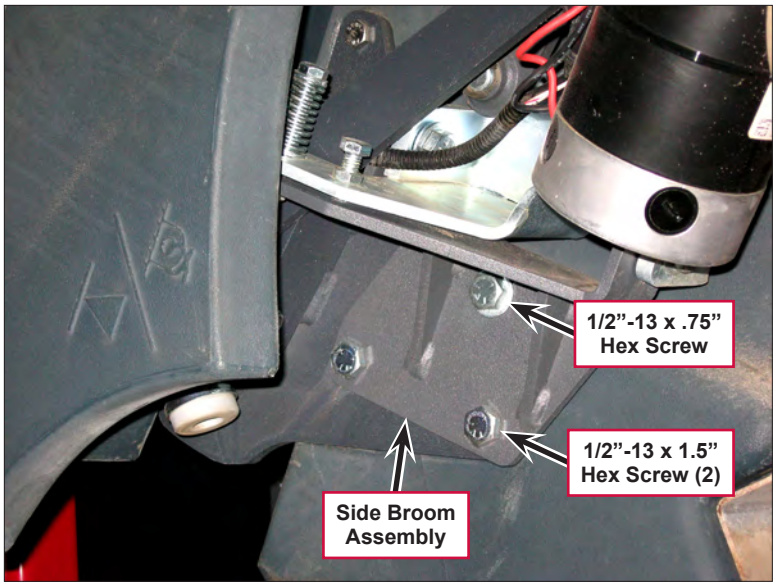
Warning! Always make sure the raised hopper is adequately supported before performing any work on or underneath the hopper.

5. Extend the side brooms in the Service Mode to access the mounting hardware.
6. Open the hopper door.
7. Remove the side broom (refer to the ***To Remove and Reinstall a Side Broom*** section).
8. Disconnect the side broom motor electrical connector. Note that you may need to cut the wire tie holding the wires to the motor.
9. Remove the **Phillips Screw** and **Nyloc® Nut** holding the **Cable Assembly** to the **Arm** on the **Side Broom Lift Weldment**.



10. Slightly loosen the **1/2”-13 x .75” Hex Screw**. Note that this screw is threaded directly into the hopper lift weldment.

11. Remove the two **1/2”-13 x 1.5” Hex Screws**, washers and Nyloc® nuts. Note that the washers and Nyloc® nuts are located inside the hopper.

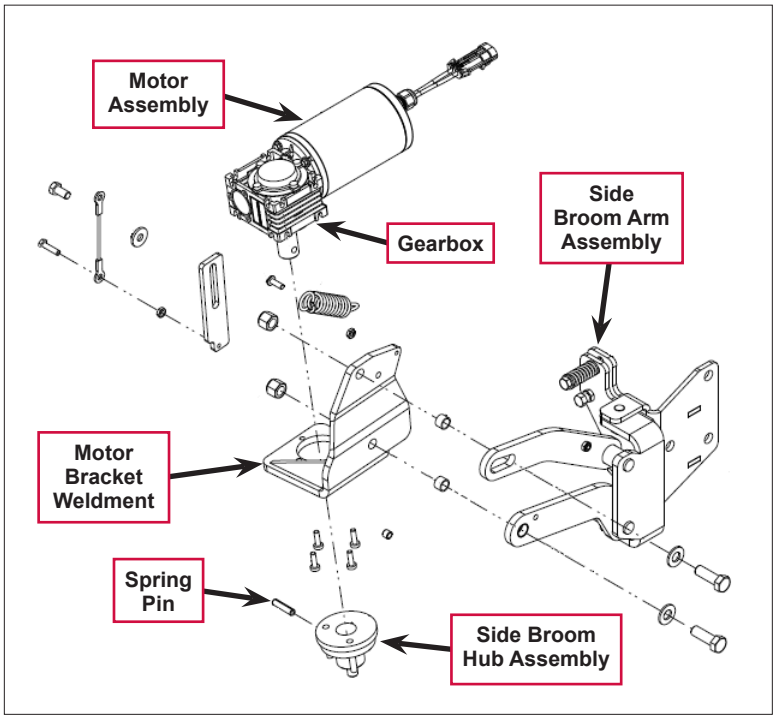


Note: *Removing the **Side Broom Assembly** is easier if one person holds the **Side Broom Assembly** in place while another person removes the **1/2”-13 x .75” Hex Screw**.*

Caution: Handle the Side Broom Assembly carefully as you remove it from the machine. The Motor Bracket Weldment and attached Motor Assembly are free to move on the Side Broom Arm Assembly and can create pinch points.

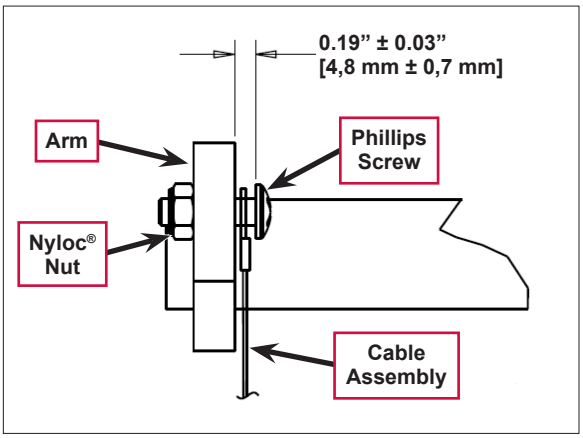
12. Remove the **1/2”-13 x .75” Hex Screw** and washer and carefully remove the **Side Broom Assembly** from the machine.

13. Reinstall the side broom motor assembly by following the above steps in reverse order.



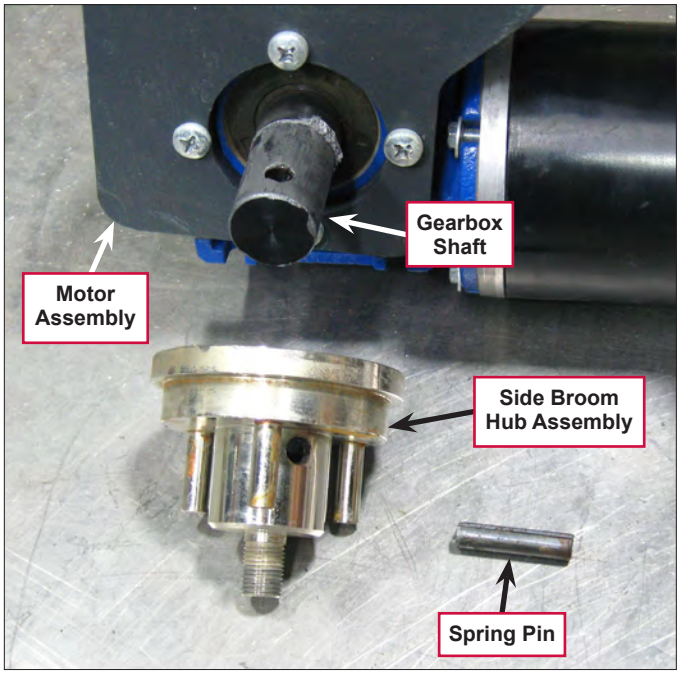
Service Note: *Use Loctite® #242 (blue) on the **1/2”-13 x .75” Hex Screw** when you reinstall the **Screw**.*

Service Note: *When you reinstall the **Cable Assembly** to the **Arm** on the side broom lift weldment, leave a 0.19” ± 0.03” [4,8 mm ± 0,7 mm] gap between the **Phillips Screw** and **Arm** to allow the **Cable Assembly** to move freely on the **Phillips Screw**.*



To Remove and Reinstall a Side Broom Hub Assembly

1. Remove the side broom motor assembly from the machine.
2. Make sure the **Motor Assembly** and **Side Broom Hub Assembly** are adequately supported, then carefully drive out the **Spring Pin**.
3. Remove the **Side Broom Hub Assembly** from the **Gearbox Shaft**.
4. Reinstall the **Side Broom Hub Assembly** by following the above steps in reverse order.



Service Note: *Coat the* ***Gearbox Shaft*** *with Never-Seez® or equivalent anti-seize compound before installing the* ***Side Broom Hub Assembly****.*

To Remove and Reinstall the Side Broom Actuator

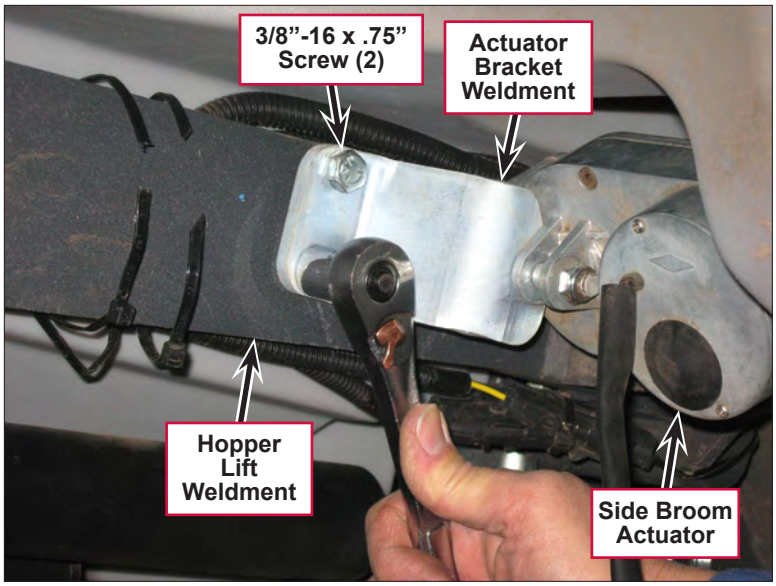
1. Dump the hopper.
2. Make sure the parking brake is engaged.
3. Turn the key switch on and switch the machine to the Service Mode.
4. Raise the hopper far enough to minimize the weight of the side brooms on the actuator, then support the hopper with jack stands or other suitable supports.

Warning! Always make sure the hopper is adequately supported before performing any work on or underneath the hopper.

5. Cut the wire tie and disconnect the side broom actuator electrical connector.

6. Remove the two **3/8”-16 x .75” Screws** holding the **Actuator Bracket Weldment** to the **Hopper Lift Weldment**.

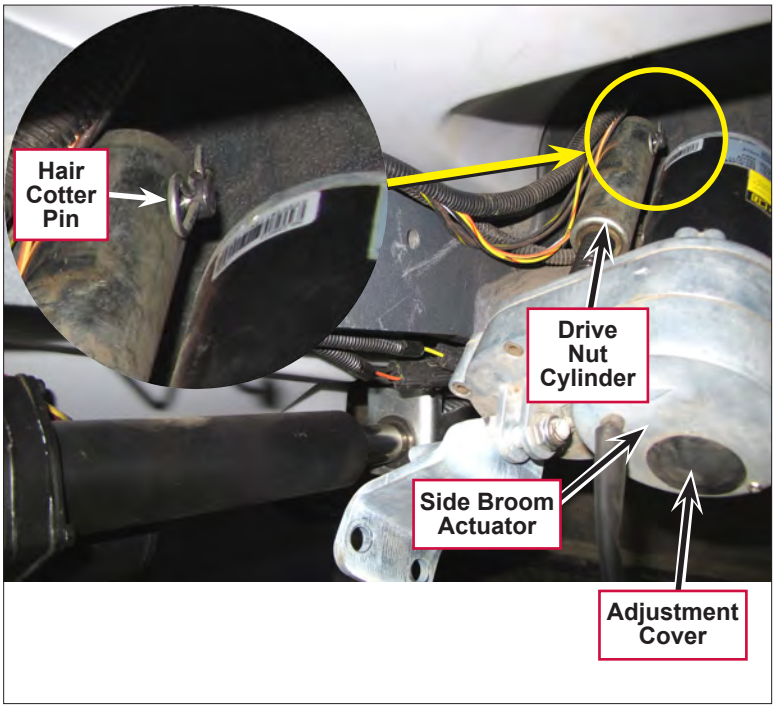
7. Extend the side brooms in the Service Mode to extend the side broom actuator. This will give you some additional clearance for better access to the hair cotter pin holding the **Side Broom Actuator** to the side broom lift weldment.



8. Use a long needle-nose pliers to remove the **Hair Cotter Pin**, then slide the **Side Broom Actuator** off of the pin on the side broom lift weldment and remove it from the machine.

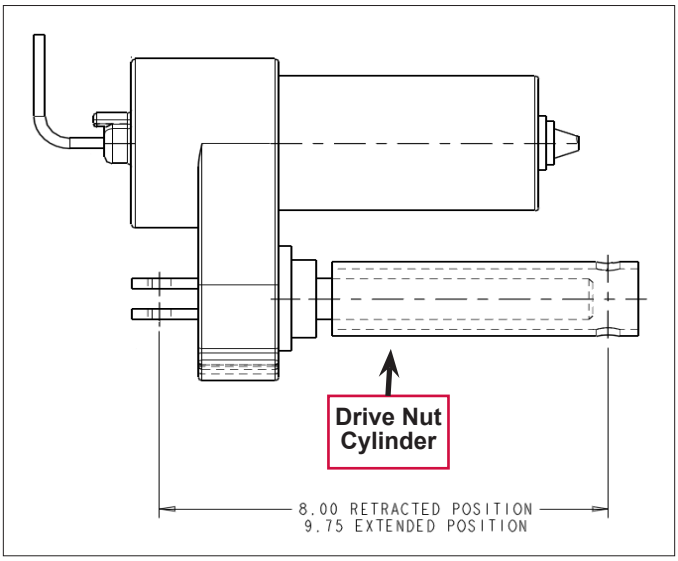
9. Reinstall the **Side Broom Actuator** by following the above steps in reverse order.

Note: *Be careful not to rotate the **Drive Nut Cylinder** on the **Side Broom Actuator** when it’s disconnected from the machine. This can change the extended and retracted positions of the **Side Broom Actuator**, and the subsequent extended and retracted positions of the side brooms.*

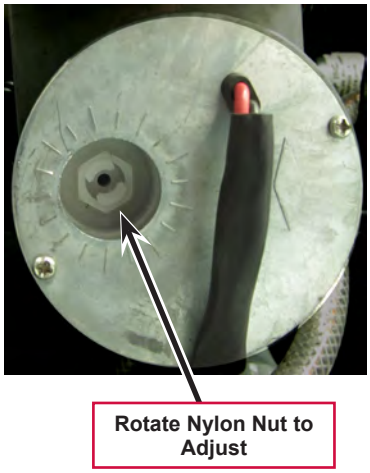


Service Note: *If you're installing a new Side Broom Actuator, or if the* ***Drive Nut Cylinder*** *on the existing Side Broom Actuator has been rotated on the Acme threaded shaft, check the actuator extended and retracted dimensions and set as follows:*

1. Reconnect the side broom actuator electrical connector.
2. Install the **Drive Nut Cylinder** onto the drive screw threads just a few turns.
3. Hold on to the drive nut cylinder to keep it from rotating, then retract the side broom actuator using the Service Mode until the motor stops.
4. Check the retracted position dimension as shown in the adjacent drawing.
5. Adjust the retracted position by rotating the **Drive Nut Cylinder** on the threaded shaft as necessary.
6. Hold on to the drive nut cylinder to keep it from rotating, then extend the side broom actuator using the Service Mode until the motor stops.
7. Check the extended position dimension.



8. If the distance is not correct, remove the rubber adjuster cover from the end of the motor. Then rotate the nylon nut found under the cover with a 1/2" (13 mm) SOCKET (Not a screwdriver!). Turning the nut one click will change the distance approximately on tenth of an inch (2.5 mm). After changing the adjustment, run the motor in and out and recheck the "extended" position dimension.



Note: Use a 1/2" (13mm) socket to turn the adjuster.

9. After each adjustment, hold the drive nut cylinder, run the actuator IN & OUT and recheck the dimensions. Reinstall the adjuster cover.

Specifications

<table>
<tr><th>Component</th><th colspan="5">Specifications</th></tr>
<tr><td rowspan="4">Side Broom Motors (all)</td><td colspan="5">No-load Speed - 2,800 RPM</td></tr>
<tr><td colspan="5">Rotation - Clockwise</td></tr>
<tr><td colspan="5">Voltage - 42 VDC</td></tr>
<tr><td colspan="5">Power - .25 HP, Continuous Duty</td></tr>
<tr><td>Side Broom Motor - Left</td><td>Current Draw (shop measurements)</td><td colspan="2">Average - 3 Amps</td><td colspan="2">Max. - 4 Amps</td></tr>
<tr><td>Side Broom Motor - Right</td><td>Current Draw (shop measurements)</td><td colspan="2">Average - 3 Amps</td><td colspan="2">Max. - 4 Amps</td></tr>
<tr><td rowspan="8">Side Broom Actuator</td><td colspan="5">36 VDC, 1/6 HP</td></tr>
<tr><td colspan="5">Motor-to-drive screw ratio - 21.7:1</td></tr>
<tr><td colspan="3" rowspan="2">Drive Nut Cylinder Positions</td><td colspan="2">Retracted Position - 8.00”</td></tr>
<tr><td colspan="2">Extended Position - 9.75”</td></tr>
<tr><td colspan="2">Current Draw (shop measurements)</td><td colspan="3">Average - 2 to 3 Amps</td></tr>
<tr><td colspan="5">Performance data for the following load conditions:</td></tr>
<tr><td>No load</td><td colspan="2">Full load</td><td colspan="2">Start</td></tr>
<tr><td>Thrust - 0 lbs</td><td colspan="2">Thrust - 600 lbs</td><td colspan="2">Thrust 600 - lbs</td></tr>
<tr><td>Speed - 39 in/min</td><td colspan="2">Speed - 30 in/min</td><td colspan="2"></td></tr>
<tr><td>Amps - 1.4 Max</td><td colspan="2">Amps - 6.7 ±1.0</td><td colspan="2"></td></tr>
</table>

Special Tools

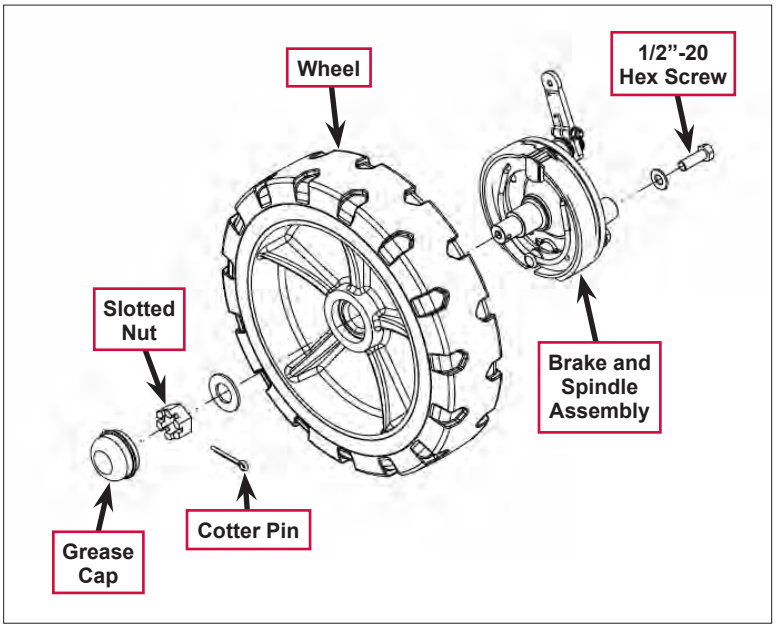
A long needle-nose pliers is recommended to remove the hair cotter pin when removing/reinstalling the side broom actuator. The photo shown here is a typical example.	

Wheel System, Non-Traction

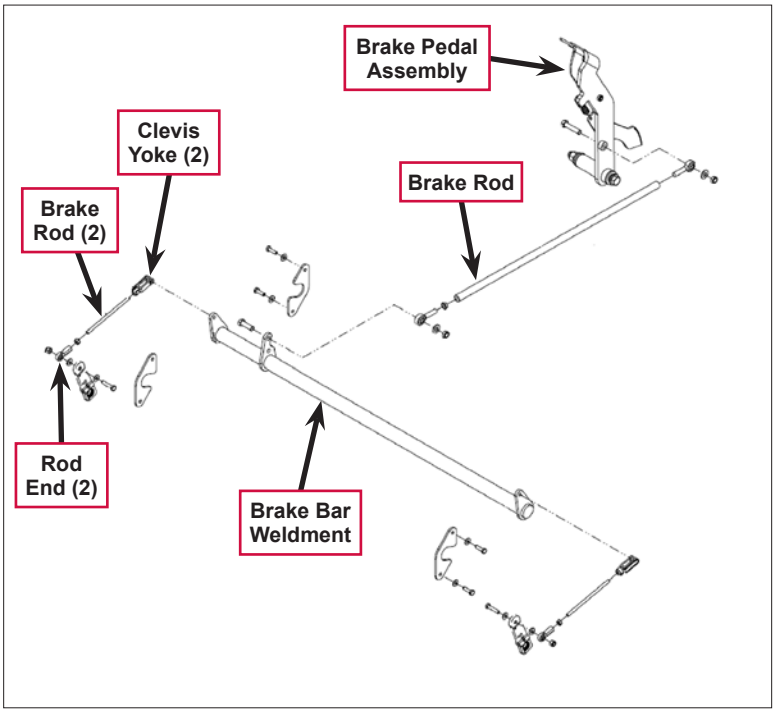
Functional Description

The non-traction wheels support the front of the machine and house the machine brakes. The wheel system includes the **Wheels**, **Brake and Spindle Assemblies** and the various mounting hardware. The wheels are mounted in the wheel wells on the front sides of the machine, between the main broom cover panels and the side brooms.

The **Wheels** are held onto the **Brake and Spindle Assemblies** with **Slotted Nuts** and **Cotter Pins**. The **Brake and Spindle Assemblies** are fastened to the machine frame with **1/2"-20 Hex Screws**.



A **Brake Rod** from the **Brake Pedal Assembly** actuates the pivoting **Brake Bar Weldment**. The **Brake Bar Weldment** actuates the two individual brake levers on the **Brake and Spindle Assemblies** via **Clevis Yokes** and attached **Brake Rods** and **Rod Ends**.

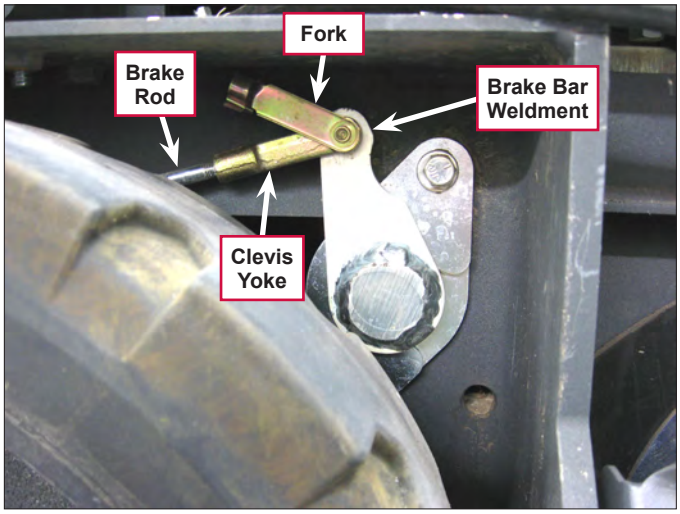


Maintenance and Adjustments

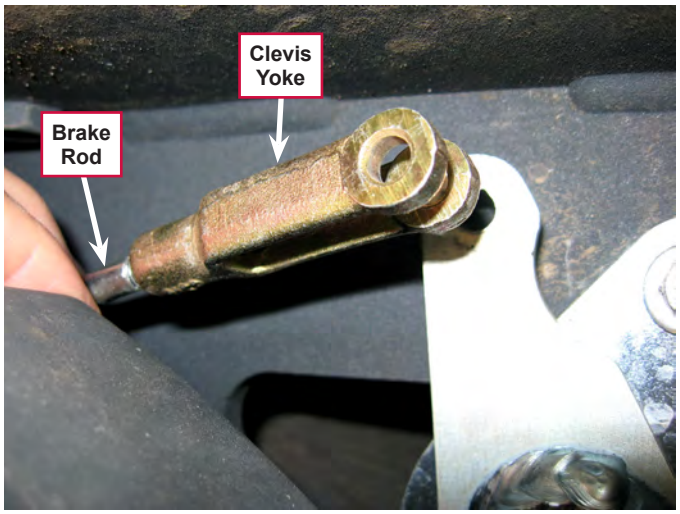
Warning! ***Before performing any maintenance or adjustments, make sure the key switch is off and the key is removed from the machine. Chock the machine wheels to prevent the machine from moving.***

To Adjust the Brakes

1. Remove the appropriate side panel to access the **Clevis Yoke**.
2. Lift the **Fork** on the **Clevis Yoke**, then pull it toward you to remove it from the **Clevis Yoke**.
3. Lift the **Clevis Yoke** out of the **Brake Bar Weldment**. This will allow the **Clevis Yoke** to rotate on the **Brake Rod**.



4. Rotate the **Clevis Yoke** on the **Brake Rod** to effectively lengthen or shorten the **Brake Rod**. Note that lengthening the **Brake Rod** will apply more pressure to the brakes with comparable brake pedal travel.
5. When the brake is adjusted correctly, reinstall the **Fork** onto the **Clevis Yoke**, then reinstall the side panel.



6. If steps 1 through 5 don't provide adequate adjustment, remove the wheel and adjust the **Rod End** as follows:

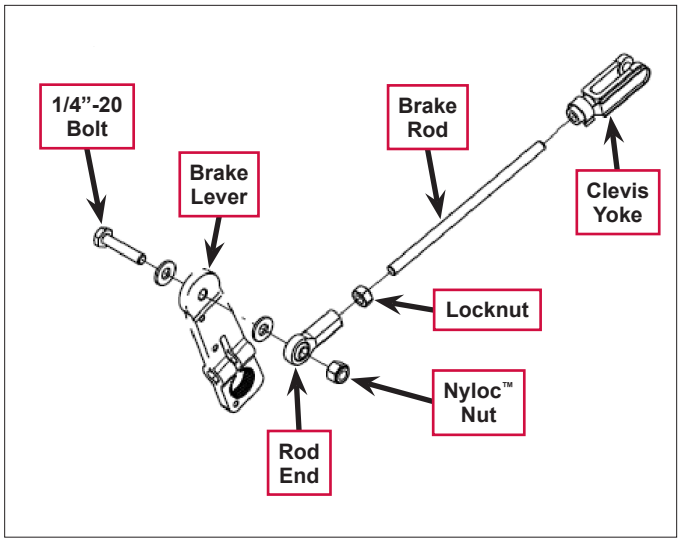
   a. Remove the **Nyloc™ Nut**, **1/4"-20 Bolt** and washers holding the **Rod End** to the **Brake Lever**.

   b. Loosen the **Locknut**.

   c. Rotate the **Rod End** on the **Brake Rod** to effectively lengthen or shorten the **Brake Rod**. Note that lengthening the **Brake Rod** will apply more pressure to the brakes with comparable brake pedal travel.

   d. When the brake is adjusted correctly, tighten the **Locknut**, then reinstall the **Rod End** onto the **Brake Lever**.

   e. Reinstall the wheel.



Troubleshooting

Problem	Cause	Correction
The wheels are making excess noise.	The wheel bearings worn.	Check the wheel, wheel bearings, and brake and spindle assembly and replace as required.
	The wheel and/or brake and spindle assembly are damaged.	
The brakes are not working correctly.	The brakes are out of adjustment	Adjust the brakes.
	The brake linings are worn out.	Replace the brake linings.

Removal and Installation

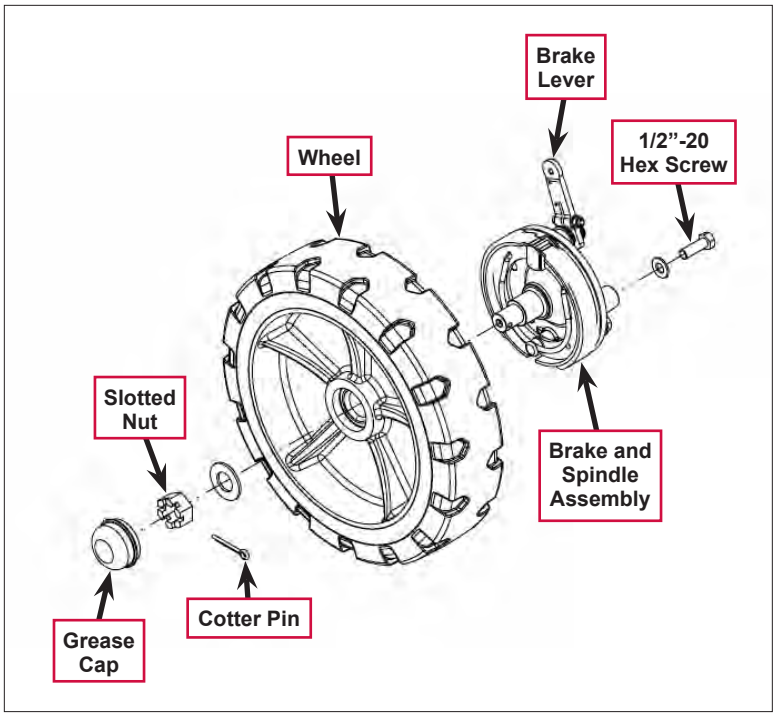
Warning! ***Before performing any maintenance or adjustments, make sure the key switch is off and the key is removed from the machine. Chock the machine wheels to prevent the machine from moving.***

Never work under a machine without safety stands or blocks to support the machine. When jacking the machine, do so at the designated Tie Down/Jacking Locations.

To Remove and Reinstall a Wheel

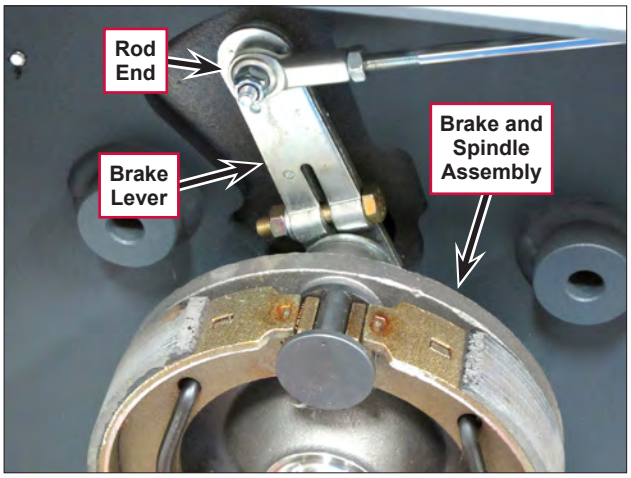
1. Jack up the machine at a designated jacking point.
2. Install safety stands or blocks to support the machine while you work on it.

3. Remove the **Grease Cap**.
4. Remove the **Cotter Pin**, **Slotted Nut** and washer.
5. Remove the **Wheel** from the **Brake and Spindle Assembly**.
6. Reinstall the **Wheel** by following the above steps in reverse order.



To Remove and Reinstall a Brake and Spindle Assembly

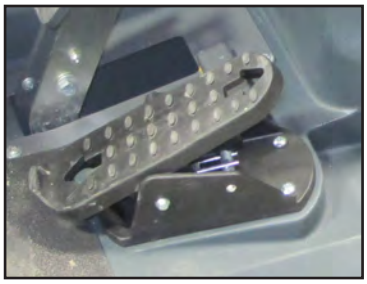
1. Jack up the machine at a designated jacking point.
2. Install safety stands or blocks to support the machine while you work on it.
3. Remove the **Wheel** from the **Brake and Spindle Assembly**.
4. Remove the Nyloc nut and 1/4”-20 screw holding the **Rod End** to the **Brake Lever**.
5. Remove the two 1/2”-20 hex screws and remove the **Brake and Spindle Assembly** from the machine.
6. Reinstall the **Brake and Spindle Assembly** by following the above steps in reverse order.



Wheel System, Traction

Functional Description

A single rear wheel provides both traction drive and steering. The major components of the drive wheel system are the drive pedal, drive controller, drive wheel motor, gearbox and drive wheel. The drive wheel is mounted to a gearbox which carries the vehicle load, provides gear reduction and converts the plane of rotation from horizontal to vertical. The gearbox is driven by a brush-less three phase AC motor. A drive controller directly operates the drive motor based on input requests from a drive pedal sensor (potentiometer) which is mounted on the side of the drive pedal. If you push the pedal forward, the machine will move forward. If you push it farther forward, the machine will increase speed. If you push the pedal backward, the machine will move in reverse. The drive pedal is spring loaded in the center or “neutral” position.



Drive Pedal

Drive Controller

Drive Wheel Motor

Gearbox and Drive Wheel

Drive Pedal

The drive pedal is spring loaded in the neutral position. The drive pedal position sensor is a potentiometer mounted on the side of the pedal that tracks the pedal position. The sensor is pre-adjusted and comes with the pedal assembly.

Drive Controller

The drive controller is a self contained sealed unit. It controls when and how the current flows to the stator windings to rotate the motor based primarily on the drive pedal sensor input, but it also monitors rotational speed sensors and a temperature sensor inside the motor.

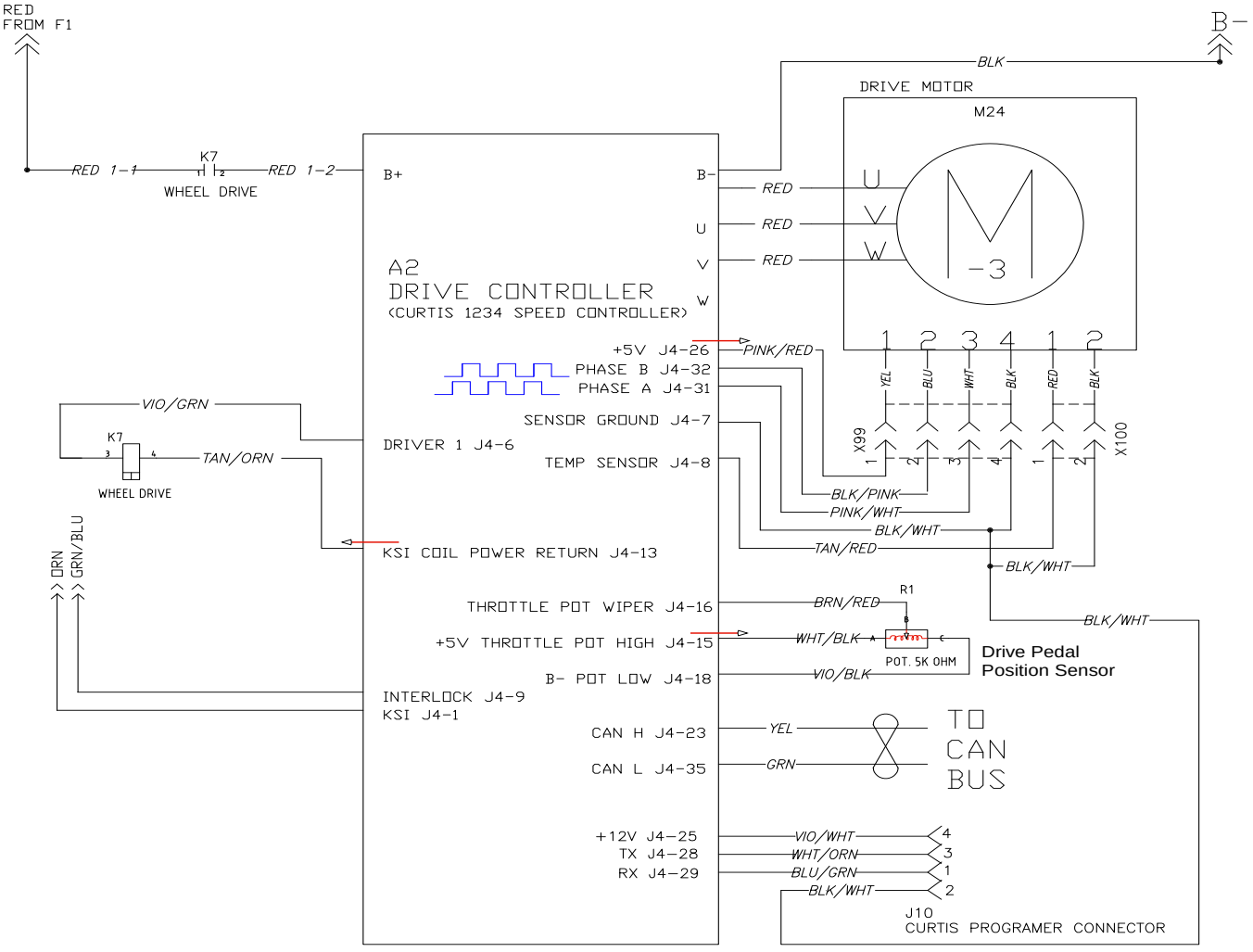
Drive Wheel Motor

The drive wheel motor is a brush-less three phase AC design. It is mounted on top of the gear box in the rear of the machine. It provides rotational power to the gear box. The wheel drive motor can change rotation direction to propel the machine both forward and backward.

Gear Box

The gear box provides gear reduction between the drive motor and the drive wheel. It converts the plane of rotation from horizontal to vertical and it supports the weight of the machine. There are no serviceable parts inside the gear box. The gear box incorporates a large turning plate bearing that allows the box to pivot in order to provide steering.

Circuit Description



Powering up the Drive Controller

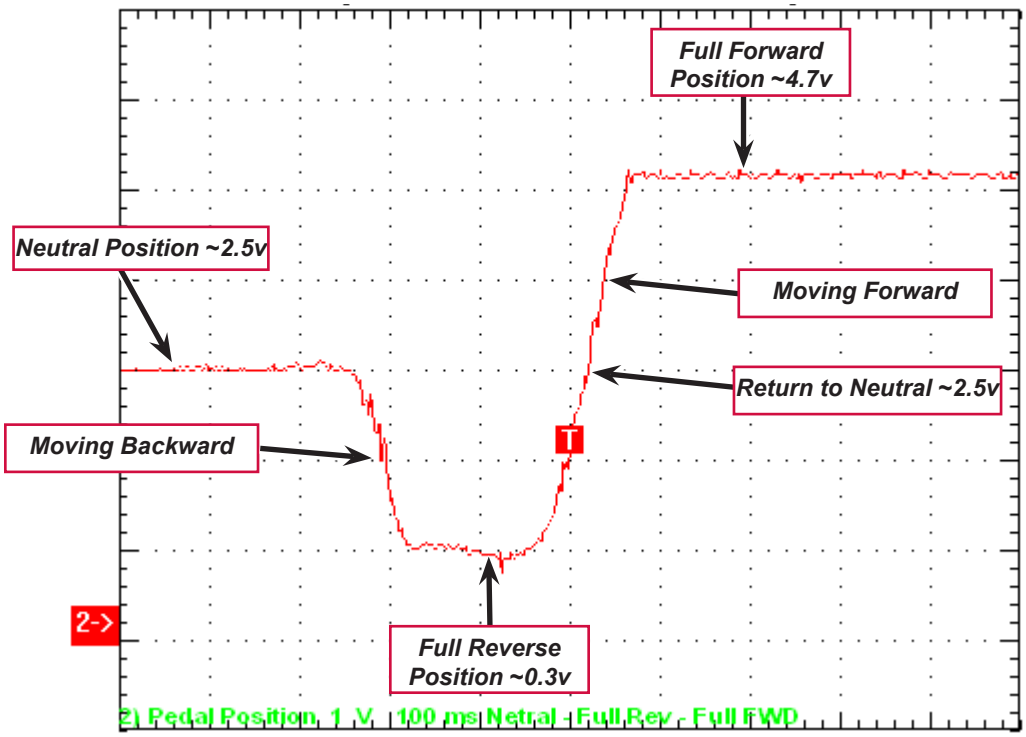
When the key switch is turned on, power is supplied on the orange wire to pin J4-1. When each interlock switch closes (seat switch, safety relay switch, emergency stop switch and battery interlock switch), power is supplied on the green/blue wire to pin J4-9. When power is available on both J4-1 and J4-9, the drive controller supplies battery voltage out of J4-13 to the K7 wheel drive contactor. The power flows through the contactor coil and back into the controller at J4-6 where it is switched to ground to energize the K7 wheel drive relay. The contacts of the energized K7 contactor supply battery power to the large B+ bolt-on

terminal of the controller. Ground (Battery Negative) is supplied to the large bolt-on B- terminal of the drive controller.

Drive Pedal Sensor

The primary sensor input is the drive pedal sensor. The drive controller supplies 5 volts out of pin J4-15 on the white/black wire to the drive pedal sensor. The voltage passes through the potentiometer resistive strip and returns to the drive controller on the violet/black wire to pin J4-18 where it is grounded inside the controller. The drive pedal sensor input (wiper) goes from the sensor on the brown/red wire to pin J4-16. When the drive pedal is in the spring loaded neutral position, the wiper is exactly in the middle of the resistive strip. This provides an input equal to 1/2 of the voltage available across the resistive strip - 2.5v. When the drive pedal moves forward, the wiper moves closer to the 5v supply increasing the input voltage. When the drive pedal moves backward, the wiper moves closer to the ground supply decreasing the input voltage.

Below is an oscilloscope waveform that shows the drive pedal sensor "sweep" starting in the neutral position, moving to full reverse then to full forward.

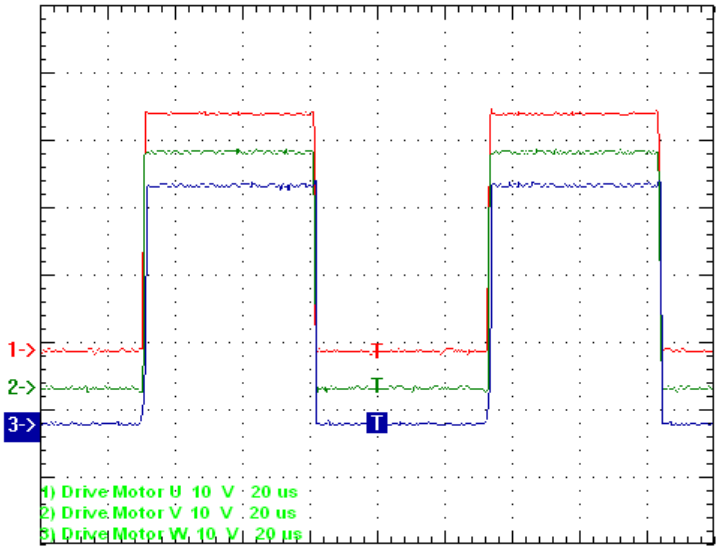


Drive Pedal Sensor Input "sweep"

Drive Motor

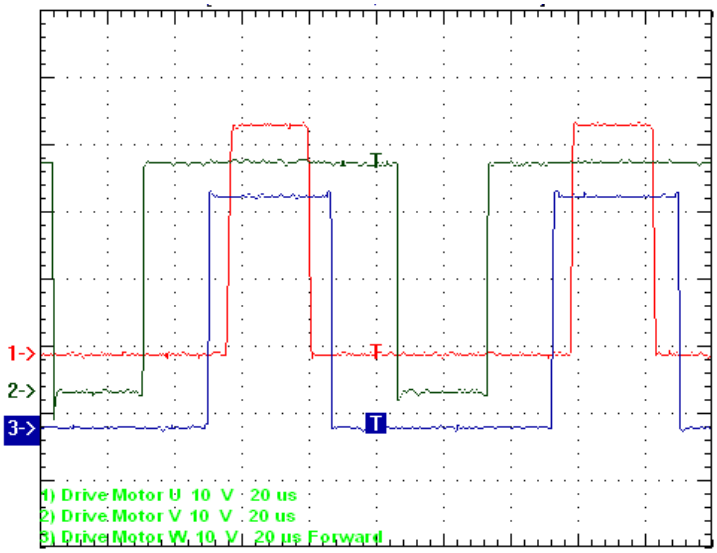
The drive controller supplies current to the drive motor stator windings on the three large U, V and W wires. When stationary, the controller pulses a current to all the motor stator windings in “unison”. This holds the motor in a fixed position. To make the motor rotate, the controller shifts the timing, duration, and current of each of the windings. This continuously changes the location and strength of the magnetic field poles created by the stator windings, which causes torque to be applied to the rotor.

Below is an oscilloscope waveform that shows the 3 phases of the motor (U, V and W) when the motor is stationary. You can see how all 3 phases are being pulsed in unison. The vertical position of each trace was adjusted to separate them for better clarity. Other wise all three would blend together as a single trace.



Drive Motor U,V and W - Stationary

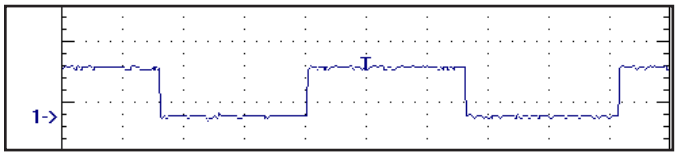
Below is an oscilloscope waveform that shows the 3 phases of the motor (U, V and W) when the motor is moving forward. You can see how each phase is now unique and no longer in unison. Again, the vertical position of each trace was adjusted to separate them for better clarity.



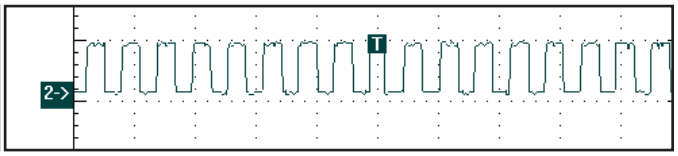
Drive Motor U,V and W - Moving Forward

The drive motor has an internal “encoder” that provides feedback to the drive controller regarding rotation direction and speed. The drive controller provides a 5v power supply out of pin J4-26 to the encoder connector pin 2. The drive controller provides an internal ground for the encoder at pin J4-7. The encoder has 2 “speed sensors”, Phase A and Phase B, that monitor the rotation of the motor shaft. Each sensor creates a 4v square wave pattern that increases in frequency as the motor rotation speed increases.

Below are oscilloscope waveforms, which show the Phase B speed sensor input when the motor is rotating slowly and when it is rotating fast.

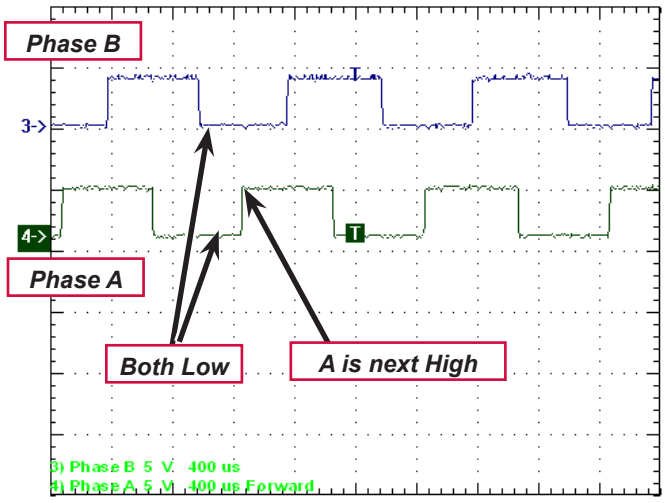


Phase B slow rotation

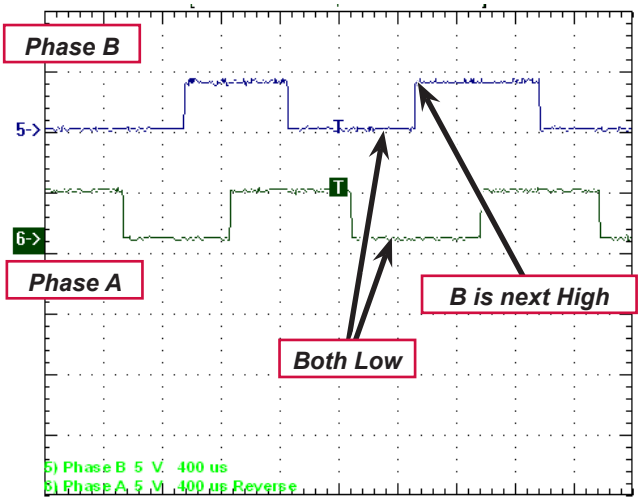


Phase B fast rotation

The signals that the speed sensors produce are slightly offset from one another. This allows the controller to verify the rotation direction of the motor. When both signals are low, the next signal that switches high (5v) indicates the rotation direction.



Forward Motion



Reverse Motion

The drive motor also has an internal temperature sensor that is monitored by the drive motor controller. The drive controller sends a 12v supply through an internal resistor and out pin J4-8 to the motor 2 wire connector pin 1. This is connected to the temperature sensor. The other side of the sensor is connected to the two wire connector pin 2. This is connected to the controller pin J4-7 where it is grounded inside the controller.

CAN Bus

The drive controller communicates with the main machine controller via the CAN Bus. The drive controller transmits error codes to the main machine controller. The main machine controller sends several messages to the drive controller that regulate machine speed mode.

The drive controller has three speed setting modes.

1. Transport - This is set at 100% of the total speed potential.
2. Scrubbing Speed - (Battery models only) This is set at 80% of the total speed potential. The user can override the scrubbing mode by pressing the speed switch.
3. Hopper Up - This is set at 50% of the total speed potential for safety reasons.

The following table explains what conditions dictate the speed mode which is used.

Condition	Battery Model - Speed Mode	Hybrid Models - Speed Mode
Hopper Up	Hopper Up	Hopper Up
Hopper Down, Not Scrubbing	Transport	Transport
Hopper Down, Scrubbing, No Override	Scrubbing	Transport
Hopper Down, Scrubbing, Override	Transport	Transport

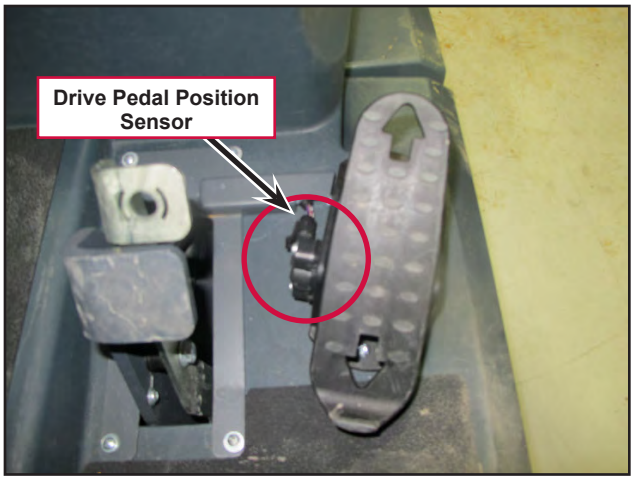
The main machine controller also communicates a special “Push Mode” request to the drive controller via the CAN Bus, when initiated by the user. Normally the drive motor “locks” the drive wheel to prevent it from rotating when in the neutral position. The push mode allows the drive wheel to turn without resistance while still allowing steering operation making it easier to tow the machine. To request the push mode, turn the key switch on while pressing and holding both the speed switch and the high pressure wand switch.

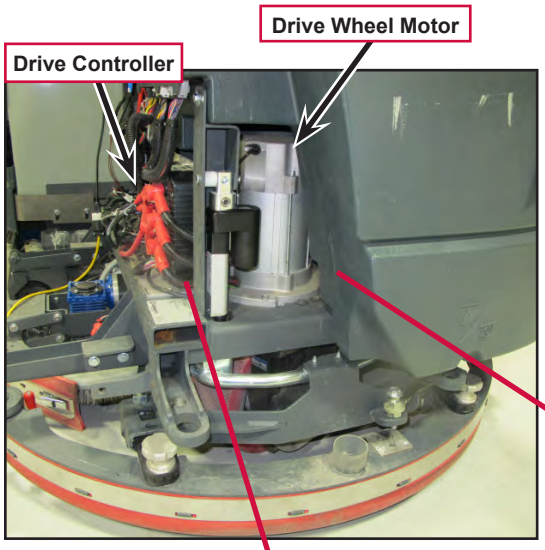
Hand Held Programmer

The drive controller can communicate with a hand held “programmer”. The controller provides power for the programmer by sending 12v out of pin J4-25 to the serial port connection pin 4. The transmit wire runs between controller pin J4-28 and serial port connection pin 3. The receive wire runs between controller pin J4-29 and serial port connection pin 1. The serial port pin 2 provides a ground for the programmer.

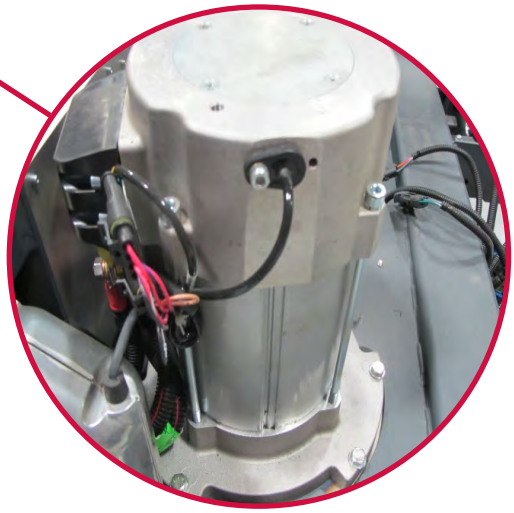
Component Locations

- Drive Pedal Position Sensor
- Drive controller
- Drive Wheel Motor





Pictured with recovery tank removed



Maintenance and Adjustments

Drive Controller

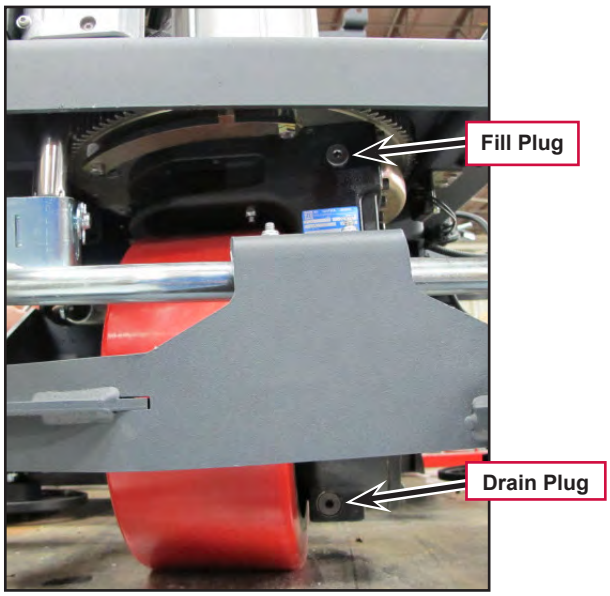
There are no user serviceable parts in Curtis 1234 controller. No attempt should be made to open, repair, or otherwise modify the controller. Doing so may damage the controller and will void the warranty. It is recommended that the controller and connections be kept clean and dry and that the controller's fault history file be checked and cleared periodically.

Drive Pedal Position Sensor

The Drive Pedal Position Sensor does not require adjustment. It comes with the pedal assembly and is pre-adjusted. If you believe it has come out of adjustment, you can adjust it using a voltmeter. With the key on and the sensor plugged in, back-probe the center "wiper" terminal with your red voltmeter lead. Connect your black voltmeter lead to battery negative. With the sensor mounting screws loose, rotate the sensor body until your voltmeter reads 2.5V then tighten the mounting screws.

Gear Box

Check the gear box oil level periodically. It should be filled to the bottom of the fill plug with 80W90 gear oil (56510411). If you want to change the oil, there is a drain plug at the bottom of the gear box.



Troubleshooting

Fault Codes

The drive controller has very robust fault code capabilities. Since most problems will result in setting a fault code, whenever there is a problem with the drive system, the first thing you should do is check for fault codes. There are three different ways to retrieve fault codes.

1. Counting the drive controller status LED flash code

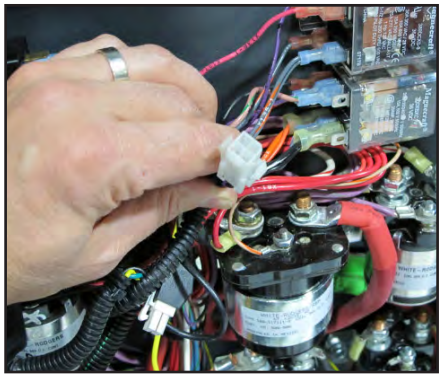
Status LEDs

   a. The pair of LEDs built into the controller (one red, one yellow) produce flash codes displaying all the currently *set* faults in a repeating cycle. Each code consists of two digits. The red LED flashes once to indicate that the first digit of the code will follow; the yellow LED then flashes the appropriate number of times for the first digit. The red LED flashes twice to indicate that the second digit of the code will follow; the yellow LED flashes the appropriate number of times for the second digit.

   b. The numerical codes used by the yellow LED are listed in the troubleshooting chart, which also lists possible fault causes and describes the conditions that *set* and *clear* each fault.

2. Use the 1311 programmer.

1311 Programmer



Serial Port Connector

   a. The 1311 programmer will display all faults that are currently *set* as well as a history of the faults that have been set since the history log was last cleared. The 1311 displays the faults by name. To use the programmer, connect it to the serial port connector located on the left side of the machine by the bank of contactors.

3. Accessing the “configuration display” mode of the hidden menu

   a. Press and hold the hazard warning flasher button down while turning on the key. Wait until the “Configuration Display” screen appears, then release the button.

   b. Press and release the scrub pressure decrease button several times until the cursor arrow is pointing at “15 Fault Recall, then press the scrub button to enter the fault recall menu.

   c. Press the scrub pressure decrease button to scroll down to “3 Speed Faults”, then press the scrub button.

   d. The Speed faults menu displays all of the fault codes that have ever been set by the drive controller and communicated to the main machine controller. The codes are displayed in “reading order”, separated by commas and are sorted with the most recent at the top left. See the ***Troubleshooting Chart*** below to look up what the code means.

   e. To exit, press the solution button.

Summary of LED display formats

The two LEDs have four different display modes, indicating the type of information they are providing.

Types of LED Display	
Display	Status
Neither LED illuminated	Controller is not powered on; or vehicle has dead battery; or severe damage.
Yellow LED flashing	Controller is operating normally.
Yellow and red LEDs both on solid	Controller is in Flash program mode.
Red LED on solid	Watchdog failure or no software loaded. Cycle KSI to restart, and if necessary load software.
Red LED and yellow LED flashing alternately	Controller has detected a fault. 2-digit code flashed by yellow LED identifies the specific fault; one or two flashes by red LED indicate whether first or second code digit will follow.

Troubleshooting Chart

The troubleshooting chart, provides the following information on all the controller faults:

- fault code
- fault name as displayed on the programmer's LCD
- the effect of the fault
- possible causes of the fault
- fault *set* conditions
- fault *clear* conditions.

Whenever a fault is encountered and no wiring or vehicle fault can be found, shut off KSI (Key Switch) and turn it back on to see if the fault *clear*s. If it does not, shut off KSI and remove the low current 35-pin connector from the drive controller. Check the connector for corrosion or damage, clean it if necessary, and re-insert it.

Note: Some of the codes listed in the table are for circuits that are not utilized on the CS7000.

Troubleshooting Chart

Flash Code #	**Programmer LCD Display**/ Effect Of Fault	Possible Cause(s)	*Set*/*Clear* Conditions
12	**Controller Overcurrent** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump	1. External short of phase U,V, or W motor connections. 2. Motor parameters are mis-tuned. 3. Controller defective.	*Set*: Phase current exceeded the current measurement limit. *Clear*: Cycle KSI.
13	**Current Sensor Fault** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1. Leakage to vehicle frame from phase U, V, or W (short in motor stator). 2. Controller defective.	*Set*: Controller current sensors have invalid offset reading. *Clear*: Cycle KSI.
14	**Precharge Failed** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1. External load on capacitor bank (B+ connection terminal) that prevents the capacitor bank from charging. 2. See Monitor menu » Battery: Capacitor Voltage.	*Set*: Precharge failed to charge the capacitor bank to the KSI voltage. *Clear*: Cycle Interlock input or use VCL function Precharge.
15	**Controller Severe Undertemp** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1. Temperature information is not accurate. 2. Controller is operating in an extreme environment.	*Set*: Heatsink temperature below -40°C. *Clear*: Bring heatsink temperature above -40°C, and cycle interlock or KSI.

Troubleshooting Chart			
Flash Code #	**Programmer LCD Display**/ Effect Of Fault	Possible Cause(s)	*Set*/*Clear* Conditions
16	**Controller Severe Overtemp** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1. Temperature information is not accurate. 2. Controller is operating in an extreme environment. 3. Excessive load on vehicle. 4. Improper mounting of controller.	*Set*: Heatsink temperature above +95°C (+203°F) *Clear*: Bring heatsink temperature below +95°C (+203°F), and cycle interlock or KSI.
17	**Severe Undervoltage** Reduced drive torque.	1. Battery Menu parameters are misadjusted. 2. Non-controller system drain on battery. 3. Battery resistance too high. 4. Battery disconnected while driving. 5. See Monitor menu » Battery: Capacitor Voltage. 6. Blown B+ fuse or main contactor did not close.	*Set*: Capacitor bank voltage dropped below the Severe Undervoltage limit with FET bridge enabled. *Clear*: Bring capacitor voltage above Severe Undervoltage limit.
18	**Severe Overvoltage** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1. Battery menu parameters are misadjusted. 2. Battery resistance too high for given regen current. 3. Battery disconnected while regen braking.	*Set*: Capacitor bank voltage exceeded the Severe Overvoltage limit with FET bridge enabled. *Clear*: Bring capacitor voltage below Severe Overvoltage limit, and then cycle KSI.
22	**Controller Overtemp Cutback** Reduced drive and brake torque.	1. See Monitor menu » Controller: Temperature. 2. Controller is performance-limited at this temperature. 3. Controller is operating in an extreme environment. 4. Excessive load on vehicle. 5. Improper mounting of controller.	*Set*: Heatsink temperature exceeded 85°C. (+185°F) *Clear*: Bring heatsink temperature below 85°C. (+185°F)

Troubleshooting Chart			
Flash Code #	**Programmer LCD Display**/ Effect Of Fault	Possible Cause(s)	*Set*/*Clear* Conditions
23	**Undervoltage Cutback** Reduced drive torque.	1. Normal operation. Fault shows that the batteries need recharging. Controller is performance limited at this voltage. 2. Battery parameters are misadjusted. 3. Non-controller system drain on battery. 4. Battery resistance too high. 5. Battery disconnected while driving. 6. See Monitor menu » Battery: Capacitor Voltage. 7. Blown B+ fuse or main contactor did not close.	*Set*: Capacitor bank voltage dropped below the Undervoltage limit with the FET bridge enabled. *Clear*: Bring capacitor voltage above the Undervoltage limit.
24	**Overvoltage Cutback** Reduced brake torque.	1. Normal operation. Fault shows that regen braking currents elevated the battery voltage during regen braking. Controller is performance limited at this voltage. 2. Battery parameters are misadjusted. 3. Battery resistance too high for given regen current. 4. Battery disconnected while regen braking. 5. See Monitor menu » Battery: Capacitor Voltage.	*Set*: Capacitor bank voltage exceeded the Overvoltage limit with the FET bridge enabled. *Clear*: Bring capacitor voltage below the Overvoltage limit.
25	**+5V Supply Failure** None, unless a fault action is programmed in Vehicle Control Language.	1. External load impedance on the +5V supply (pin 26) is too low. 2. See Monitor menu » outputs: 5 Volts and Ext Supply Current.	*Set*: +5V supply (pin 26) outside the +5V±10% range. *Clear*: Bring voltage within range.
26	**Digital Out 6 Overcurrent** Digital Output 6 driver will not turn on. *Note: This circuit is not used on the CS7000*	1. External load impedance on Digital Output 6 driver (pin 19) is too low.	*Set*: Digital Output 6 (pin 19) current exceeded 15 mA. *Clear*: Remedy the overcurrent cause and use the VCL function *Set*_DigOut() to turn the driver on again.

Troubleshooting Chart			
Flash Code #	**Programmer LCD Display**/ Effect Of Fault	Possible Cause(s)	*Set*/*Clear* Conditions
27	**Digital Out 7 Overcurrent** Digital Output 7 driver will not turn on. *Note: This circuit is not used on the CS7000*	1. External load impedance on Digital Output 7 driver (pin 20) is too low.	*Set*: Digital Output 7 (pin 20) current exceeded 15 mA. *Clear*: Remedy the overcurrent cause and use the VCL function *Set*_DigOut() to turn the driver on again.
28	**Motor Temp Hot Cutback** Reduced drive torque.	1. Motor temperature is at or above the programmed Temperature Hot setting, and the requested current is being cut back. 2. Motor Temperature Control Menu parameters are mis-tuned. 3. See Monitor menu » Motor: Temperature and » Inputs: Analog2. 4. If the application doesn't use a motor thermistor, Temp Compensation and Temp Cutback should be programmed Off.	*Set*: Motor temperature is at or above the Temperature Hot parameter *set*ting. *Clear*: Bring the motor temperature within range.
29	**Motor Temp Sensor Fault** MaxSpeed reduced (LOS, Limited Operating Strategy), and motor temperature cutback disabled.	1. Motor thermistor is not connected properly. 2. If the application doesn't use a motor thermistor, Motor Temp Sensor Enable should be programmed Off. 3. See Monitor menu » Motor: Temperature and » Inputs: Analog2.	*Set*: Motor thermistor input (pin 8) is at the voltage rail (0 or 10V). *Clear*: Bring the motor thermistor input voltage within range.
31	**K7 Wheel Drive Contactor Coil Driver Open/Short** ShutdownDriver1.	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set*: Driver 1 (pin 6) is either open or shorted. (Pin 6 is the K7 wheel drive contactor coil driver circuit.) This fault can be set only when Main Enable = Off. *Clear*: Correct open or short, and cycle driver.

Troubleshooting Chart			
Flash Code #	**Programmer LCD Display**/ Effect Of Fault	Possible Cause(s)	*Set*/*Clear* Conditions
31	**Main Open/Short** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set*: Main contactor driver (pin 6) is either open or shorted. (Pin 6 is the K7 wheel drive contactor coil driver circuit) This fault can be *set* only when Main Enable = On. *Clear*: Correct open or short, and cycle driver
32	**Coil2 Driver Open/Short** ShutdownDriver2. *Note: This circuit is not used on the CS7000*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set*: Driver 2 (pin 5) is either open or shorted. This fault can be *set* only when EM Brake Type = 0. *Clear*: Correct open or short, and cycle driver.
32	**EMBrake Open/Short** ShutdownEMBrake; ShutdownThrottle; FullBrake. *Note: This circuit is not used on the CS7000*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set*: Electromagnetic brake driver (pin 5) is either open or shorted. This fault can be *set* only when EM Brake Type > 0. *Clear*: Correct open or short, and cycle driver.
33	**Coil3 Driver Open/Short** ShutdownDriver3. *Note: This circuit is not used on the CS7000*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set*: Driver 3 (pin 4) is either open or shorted. *Clear*: Correct open or short, and cycle driver.
34	**Coil4 Driver Open/Short** ShutdownDriver4. *Note: This circuit is not used on the CS7000*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set*: Driver 4 (pin 3) is either open or shorted. *Clear*: Correct open or short, and cycle driver.
35	**PD Open/Short** ShutdownPD. *Note: This circuit is not used on the CS7000*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set*: Proportional driver (pin 2) is either open or shorted. *Clear*: Correct open or short, and cycle driver.
36	**Encoder Fault** ShutdownEMBrake.	1. Motor encoder failure. 2. Bad crimps or faulty wiring. 3. See Monitor menu » Motor: Motor RPM.	*Set*: Motor encoder phase failure detected. *Clear*: Cycle KSI.

Troubleshooting Chart			
Flash Code #	**Programmer LCD Display**/ Effect Of Fault	Possible Cause(s)	*Set*/*Clear* Conditions
37	**Motor Open** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1. Motor phase is open. 2. Bad crimps or faulty wiring.	*Set*: Motor phase U, V, or W detected open. *Clear*: Cycle KSI.
38	**K7 Wheel Drive Contactor Welded** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1. K7 Wheel Drive contactor tips are welded closed. 2. Motor phase U or V is disconnected or open. 3. An alternate voltage path (such as an external precharge resistor) is providing a current to the capacitor bank (B+ connection terminal).	*Set*: Just prior to the K7 wheel drive contactor closing, the capacitor bank voltage (B+ connection terminal) was loaded for a short time and the voltage did not discharge. *Clear*: Cycle KSI
39	**Main Contactor Did Not Close** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1. Main contactor did not close. 2. Main contactor tips are oxidized, burned, or not making good contact. 3. External load on capacitor bank (B+ connection terminal) that prevents capacitor bank from charging. 4. Blown B+ fuse.	*Set*: With the main contactor commanded closed, the capacitor bank voltage (B+ connection terminal) did not charge to B+. *Clear*: Cycle KSI.
41	**Throttle Wiper High** ShutdownThrottle.	1. See Monitor menu » Inputs: 2. Throttle Pot. wiper voltage too high.	*Set*: Throttle pot wiper (pin 16) voltage is higher than the high fault threshold (can be changed with the VCL function Setup_ Pot_Faults). *Clear*: Bring throttle pot wiper voltage below the fault threshold.
42	**Throttle Wiper Low** ShutdownThrottle.	1. See Monitor menu » Inputs: Throttle Pot. 2. Throttle pot wiper voltage too low.	*Set*: Throttle pot wiper (pin 16) voltage is lower than the low fault threshold (can be changed with the VCL function *Set*up_ Pot_Faults). *Clear*: Bring throttle pot wiper voltage above the fault threshold.

Troubleshooting Chart			
Flash Code #	**Programmer LCD Display**/ Effect Of Fault	Possible Cause(s)	*Set*/*Clear* Conditions
43	**Pot2 Wiper High** FullBrake. *Note: This circuit is not used on the CS7000*	1. See Monitor menu » Inputs: Pot2 Raw. 2. Pot2 wiper voltage too high.	*Set*: Pot2 wiper (pin 17) voltage is higher than the high fault threshold (can be changed with the VCL function *Set*up_Pot_ Faults()). *Clear*: Bring Pot2 wiper voltage below the fault threshold.
44	**Pot2 Wiper Low** FullBrake. *Note: This circuit is not used on the CS7000*	1. 1. See Monitor menu » Inputs: Pot2 Raw. 2. 2. Pot2 wiper voltage too low.	*Set*: Pot2 wiper (pin 17) voltage is lower than the low fault threshold (can be changed with the VCL function *Set*up_Pot_ Faults()). *Clear*: Bring Pot2 wiper voltage above the fault threshold.
45	**Pot Low Overcurrent** ShutdownThrottle; FullBrake.	1. See Monitor menu » Outputs: Pot Low. 2. Combined pot resistance connected to pot low is too low.	*Set*: Pot low (pin 18) current exceeds 10mA. *Clear*: *Clear* pot low overcurrent condition and cycle KSI.
46	**EEPROM Failure** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.	1. Failure to write to EEPROM memory. This can be caused by EEPROM memory writes initiated by VCL (Vehicle Control Language), by the CAN Bus, by adjusting parameters with the programmer, or by loading new software into the controller.	*Set*: Controller operating system tried to write to EEPROM memory and failed. *Clear*: Download the correct software (OS) and matching parameter default settings into the controller and cycle KSI.
47	**HPD/Sequencing Fault** ShutdownThrottle.	1. KSI, interlock, direction, and throttle inputs applied in incorrect sequence. 2. Faulty wiring, crimps, or switches at KSI, interlock, direction, or throttle inputs. 3. See Monitor menu » Inputs.	*Set*: HPD (High Pedal Disable) or sequencing fault caused by incorrect sequence of KSI, interlock, direction, and throttle inputs. *Clear*: Reapply inputs in correct sequence.

Troubleshooting Chart			
Flash Code #	**Programmer LCD Display**/ Effect Of Fault	Possible Cause(s)	*Set*/*Clear* Conditions
47	**Emer Rev HPD** ShutdownThrottle; ShutdownEMBrake.	1. Emergency Reverse operation has concluded, but the throttle, forward and reverse inputs, and interlock have not been returned to neutral.	*Set*: At the conclusion of Emergency Reverse, the fault was *set* because various inputs were not returned to neutral. *Clear*: If EMR_Interlock = On, *clear* the interlock, throttle, and direction inputs. If EMR_Interlock = Off, *clear* the throttle and direction inputs.
49	**Parameter Change Fault** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1. This is a safety fault caused by a change in certain parameter settings so that the vehicle will not operate until KSI is cycled. For example, if a user changes the Throttle Type this fault will appear and require cycling KSI before the vehicle can operate.	*Set*: Adjustment of a parameter setting that requires cycling of KSI. *Clear*: Cycle KSI.
51	**High Pedal Disable** ShutdownMotor;	1. There is an open in the interlock circuit J4-9 (Seat Switch, Emergency Switch, Battery Interlock, Steering Safety Relay).	*Set*: The drive pedal is outside of the neutral position when there is no voltage to the interlock circuit J4-9 *Clear*: Voltage is supplied to the interlock circuit pin J4-9 and the drive pedal is returned to neutral.
68	**VCL (Vehicle Control Language) Run Time Error** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.	1. VCL code encountered a runtime VCL error. 2. See Monitor menu » Controller: VCL Error Module and VCL Error. This error can then be compared to the runtime VCL module ID and error code definitions found in the specific OS system information file.	*Set*: Runtime VCL code error condition. *Clear*: Edit VCL application software to fix this error condition; flash the new compiled software and matching parameter defaults; cycle KSI.

Troubleshooting Chart			
Flash Code #	**Programmer LCD Display**/ Effect Of Fault	Possible Cause(s)	*Set*/*Clear* Conditions
69	**External Supply Out of Range** None, unless a fault action is programmed in VCL.	1. External load on the 5V and 12V supplies draws either too much or too little current. 2. Fault Checking Menu parameters Ext Supply Max and Ext Supply Min are mis-tuned. 3. See Monitor menu » Outputs: Ext Supply Current.	*Set*: The external supply current (combined current used by the 5V supply [pin and 12V supply [pin 25]) is either greater than the upper current threshold or than the lower current threshold. The thresholds are defined by the External Supply Max and External Supply Min parameter settings. *Clear*: Bring the external supply current within range.
71	**OS General** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.	1. Internal controller fault.	*Set*: Internal controller fault detected. *Clear*: Cycle KSI.
72	**PDO Timeout** ShutdownInterlock; CAN NMT State *set* to Pre-operational.	1. Time between CAN PDO messages received exceeded the PDO Timeout Period.	*Set*: Time between CAN PDO messages received exceeded the PDO Timeout Period. *Clear*: Cycle KSI or receive CAN NMT message.
73	**Stall Detected** ShutdownEMBrake; Control Mode changed to LOS (Limited Operating Strategy).	1. Stalled motor. 2. Motor encoder failure. 3. Bad crimps or faulty wiring. 4. Problems with power supply for the motor encoder. 5. See Monitor menu » Motor: Motor RPM.	*Set*: No motor encoder movement detected. *Clear*: Either cycle KSI, or detect valid motor encoder signals while operating in LOS mode and return Throttle Command = 0 and Motor RPM = 0.
74	**Fault On Other Traction Controller** *Note: Not used on CS7000*	1. Dual Drive fault: see Dual Drive manual.	
75	**Dual Severe Fault** *Note: Not used on CS7000*	1. Dual Drive fault: see Dual Drive manual.	

Troubleshooting Chart			
Flash Code #	**Programmer LCD Display**/ Effect Of Fault	Possible Cause(s)	*Set*/*Clear* Conditions
87	**Motor Characterization Fault** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1. Motor characterization failed during characterization process. See Monitor menu » Controller: Motor Characterization Error for cause: 0=none 1=encoder signal seen, but step size not determined; *set* Encoder Step Size manually 2=motor temp sensor fault 3=motor temp hot cutback fault 4= controller overtemp cutback fault 5=controller undertemp cutback fault 6=undervoltage cutback fault 7=severe overvoltage fault 8=encoder signal not seen, or one both channels missing 9=motor parameters out of characterization range.	*Set*: Motor characterization failed during the motor characterization process. *Clear*: Correct fault; cycle KSI.
89	**Motor Type Fault** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1. The Motor_Type parameter value is out of range.	*Set*: Motor_Type parameter is *set* to an illegal value. *Clear*: *Set* Motor_Type to correct value and cycle KSI.
91	**VCL/OS Mismatch** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake; ShutdownPump.	1. The VCL software in the controller does not match the OS software in the controller.	*Set*: VCL and OS software do not match; when KSI cycles, a check is made to verify that they match and a fault is issued when they do not. *Clear*: Download the correct VCL and OS software into the controller.
92	**EM Brake Failed to Set** ShutdownEMBrake; ShutdownThrottle.	1. Vehicle movement sensed after the EM Brake has been commanded to *set*. 2. EM Brake will not hold the motor from rotating.	*Set*: After the EM Brake was commanded to *set* and time has elapsed to allow the brake to fully engage, vehicle movement has been sensed. *Clear*: Activate the throttle.

Troubleshooting Chart			
Flash Code #	**Programmer LCD Display**/ Effect Of Fault	Possible Cause(s)	*Set*/*Clear* Conditions
93	**Encoder LOS (Limited Operating Strategy)** Enter LOS control mode.	1. Limited Operating Strategy control mode has been activated, a result of either an Encoder (Code 36) or a Stall Detect (Code 73). 2. Motor encoder failure. 3. Bad crimps or faulty wiring. 4. Vehicle is stalled.	*Set*: Encoder Fault (Code 36) or Stall Detect Fault (Code 73) was activated, and Brake or Interlock has been applied to activate LOS control mode, allowing limited motor control. *Clear*: Cycle KSI or, if LOS mode was activated by the Stall Fault, *clear* by ensuring encoder senses proper operation, Motor RPM = 0, and Throttle Command = 0.
94	**Emer Rev Timeout** ShutdownEMBrake; ShutdownThrottle.	1. Emergency Reverse was activated and concluded because the EMR Timeout timer has expired. 2. The emergency reverse input is stuck On.	*Set*: Emergency Reverse was activated and ran until the EMR Timeout timer expired. *Clear*: Turn the emergency reverse input Off.
98	**Illegal Model Number** ShutdownMotor; ShutdownMainContactor; ShutdownEMBrake; ShutdownThrottle; FullBrake; ShutdownPump.	1. Model_Number variable contains illegal value (not 1234, 1236, 1238, or 1298). 2. Software and hardware do not match. 3. Controller defective.	*Set*: Illegal Model_Number variable; when KSI cycles, a check is made to confirm a legal Model_Number, and a fault is issued if one is not found. *Clear*: Download appropriate software for your controller model.
99	**Dualmotor Parameter Mismatch** *Note: Not used on CS7000*	1. Dual Drive fault: see Dual Drive manual.	

Fault History

The 1311 programmer can be used to access the controller's fault history file. The programmer will read out all the faults the controller has experienced since the last time the fault history file was cleared. Faults such as contactor faults may be the result of loose wires; contactor wiring should be carefully checked. Faults such as over temperature may be caused by operator habits or by overloading.

Removal and Installation

Drive Pedal Assembly

1. Disconnect drive pedal position sensor electrical connector.
2. Remove drive pedal mounting screws.
3. Remove pedal assembly.
4. Reassemble in reverse order.
5. Validate the drive pedal sensor adjustment and adjust if necessary.
   a. Use Service Mode to view the sensor voltage in the control panel LCD. See: ***Control System, Service Mode*** for instructions on how to enter the service mode.

   b. The drive pedal sensor voltage should be between 2.4v and 2.6v when in the center “neutral” position.
   c. If the voltage is not within the correct range, loosen the sensor mounting screws and rotate the sensor to achieve the correct value. Then, tighten down the mounting screws.

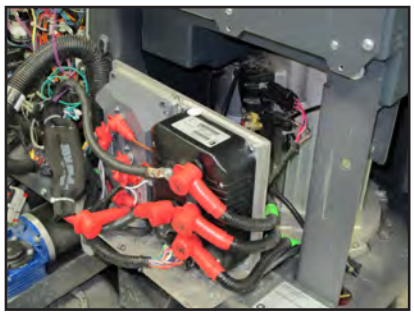
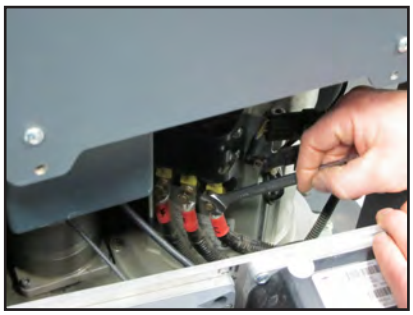
Drive Motor and Gearbox Assembly

The drive motor, gearbox and drive wheel are removed as an assembly out of the bottom of the machine. Once removed, separate the motor from the gearbox.

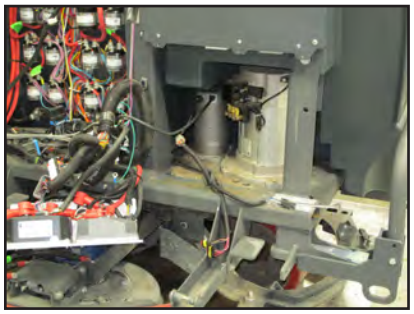
1. Remove the squeegee tool.
2. Remove the recovery tank and hose.
3. Turn the key switch on and press the vacuum button to lower the squeegee support.
4. Unplug the squeegee actuator electrical connector, then turn off the key. Remove the squeegee actuator.

5. Disconnect the main power connector.

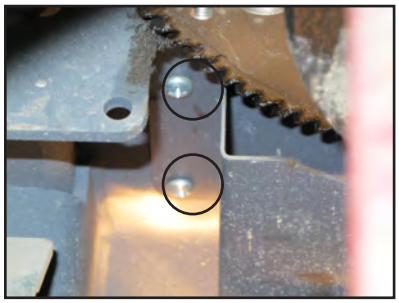
6. Disconnect all of the main machine controller connectors and pull the harness aside. Remove the controller mounting bracket fasteners and pull it away to gain access to the drive motor wiring. Label the drive motor cables for proper reassembly, then remove them from the motor.

7. Swing the controller bracket assembly out of the way (reposition the steering motor wiring as needed).



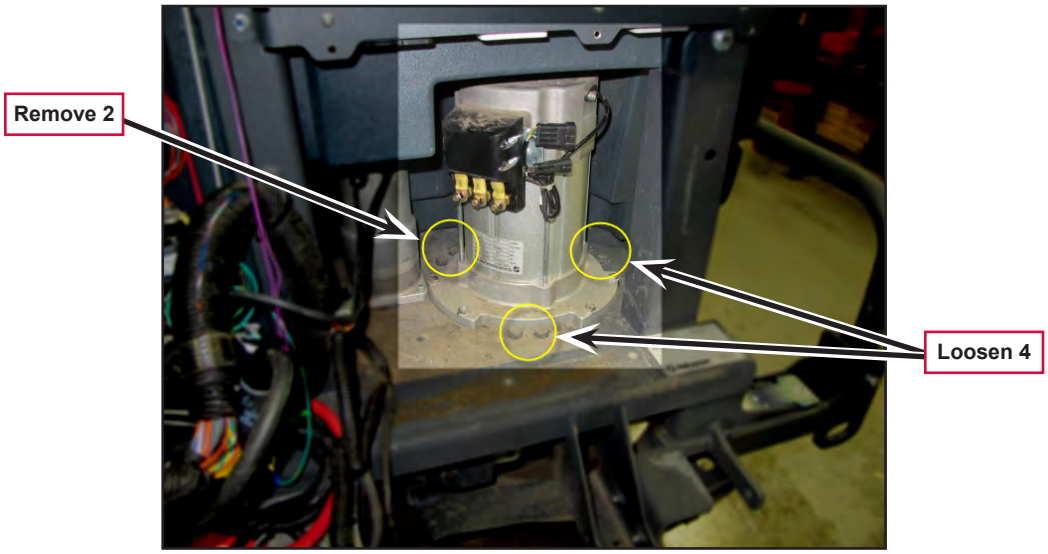
8. Working from under the machine, remove the cover plate that is under the steering drive gear. There are two screws on each side.



9. Lift the squeegee lift bar and tie it up.

10. Block drive wheel with wheel chocks on both sides so that it cannot roll.

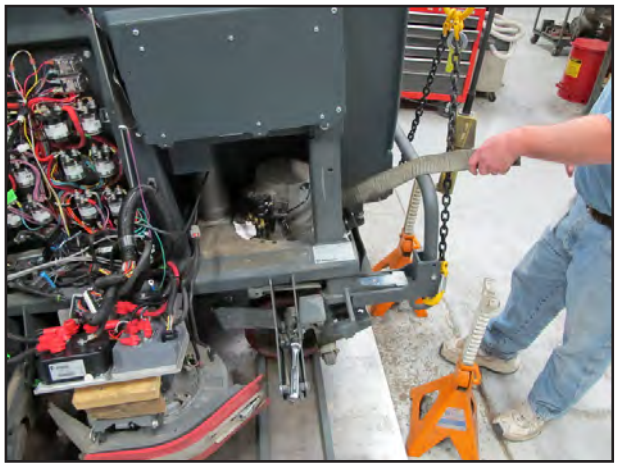
11. Remove the 2 inner gear box to frame bolts and loosen the remaining 4.



12. Lift the machine just enough to take weight off the gear box and remove the remaining 4 gear box to frame bolts.

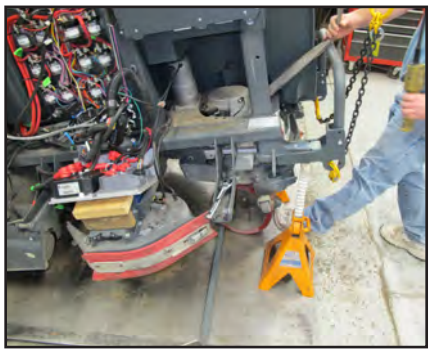
13. Attach a lifting strap around the drive motor. You will use the strap to guide and lower the assembly.

14. Slowly lift the machine up to allow the drive motor and gear box assembly to come out the bottom while holding the motor assembly upright using the lifting strap.



15. Secure the machine safely on jack stands.

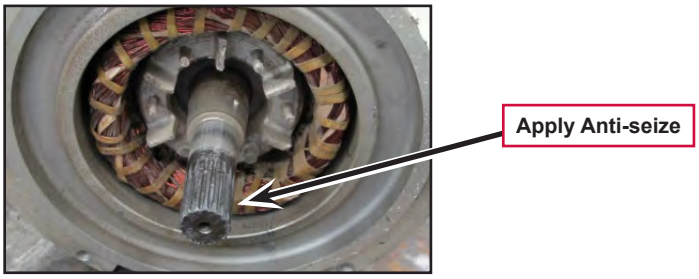
16. Hook up a hoist to the lift strap and put a slight tension on the strap. Remove the rear wheel chock and allow the assembly to roll backward and downward out of the machine controlling the movement by lowering the hoist and blocking the wheel.



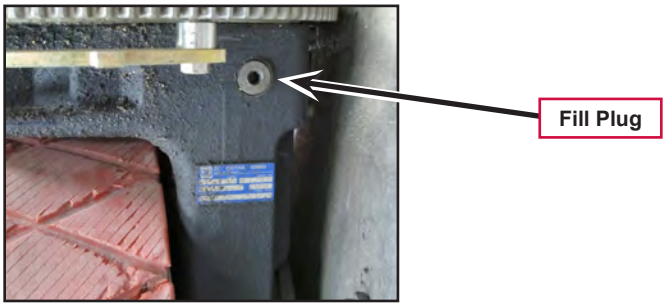
17. To separate the motor from the gear box, remove the attaching screws and pry apart.

18. Reassembly notes:

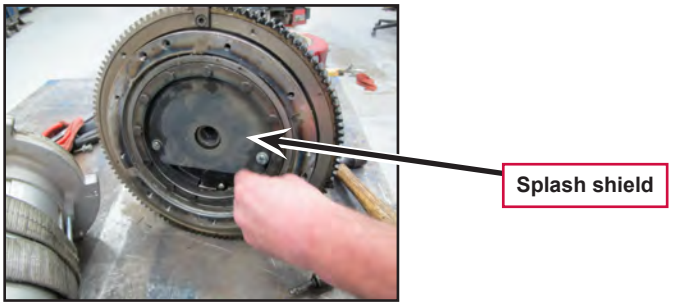
    a. Be sure to apply anti-seize compound to the motor shaft splines and gearbox splines.



    b. If installing a new gear box, be sure to fill it to the bottom of the fill plug with 80W90 oil when the assembly is installed.. Holds 2.2L (.59 Gal) (Part number 56510411).



c. If installing a new gear box, be sure to transfer the splash shield.



d. Apply 56510412 (OPEN GEAR LUBE) to front 180° of ring gear teeth and all around pinion gear teeth.

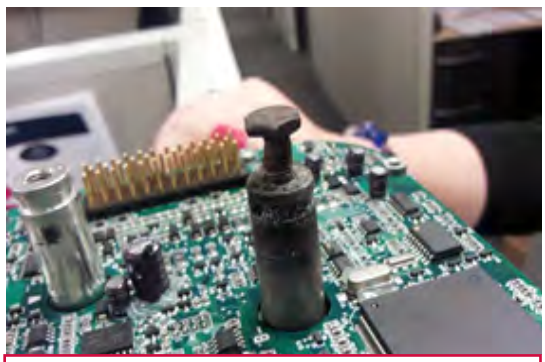
19. Reassemble in reverse order.

Drive Wheel

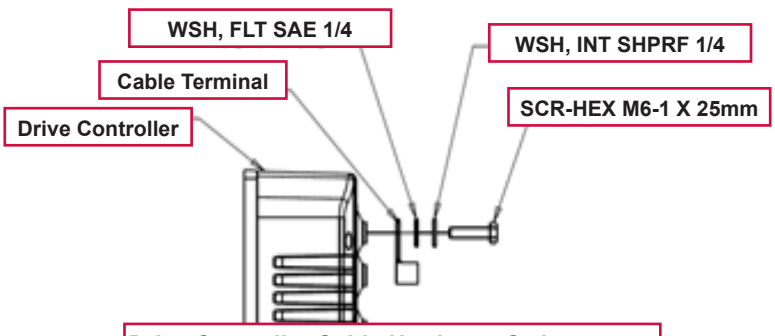
1. Block front wheels
2. Loosen drive wheel lug nuts.
3. Jack the rear of the machine up to get the drive wheel off the ground.
4. Remove the drive wheel lug nuts and remove the wheel.
5. Reassemble in reverse order.

Drive Controller

1. Disconnect the main power connector.
2. Remove the recovery tank.
3. Label the power and motor cables to aid in correct reassembly.
4. Remove the bolts securing the motor and power cables.
5. Disconnect the low current connector.
6. Remove controller attaching screws and remove the controller.
7. Reassemble in reverse order. When attaching cables use the correct hardware in the correct order to avoid damage caused from a loose connection. Torque to 90 IN-LBS (10.17 Nm).



Damaged Drive Controller terminal from loose connection. (Case removed for clarity)



Drive Controller Cable Hardware Order

Specifications

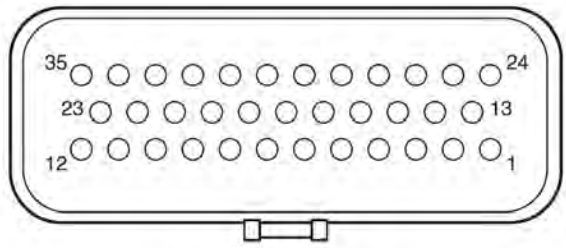
Shop Measurements

Shop measurements are values that were measured on a real machine. While they are not “specifications”, they can help you recognize normal vs abnormal.

Drive Controller Voltage Measurements

All voltages are DC unless otherwise stated and were measured with the negative (black) voltmeter lead on battery negative and the key switch on.

Low Current 35 Pin Connector (J4)



Pin	Wire Color	Circuit	Voltage
1	ORN	Key switch input. Provides logic power for the controller and power for the coil drivers.	38.12 V
2		Not Used	
3		Not Used	
4		Not Used	
5		Not Used	
6	VIO/GRN	K7 Wheel Drive Contactor Driver	Momentary 38 V at first key on. 5-6v when contactor is “on”
7	BLK/PINK	Input and output ground reference.	0.008 V
8	TAN/RED	Motor Temperature Sensor	1.22 V (Room Temp) 12 V (open circuit)
9	GRN/BLU	Interlock Switch Input	38.8 V
10		Not Used	
11		Not Used	
12		Not Used	
13	TAN/RED	K7 Wheel Drive Contactor Coil Power	38.18 V
14		Not Used	
15	WHT/BLK	Throttle POT High (5 V supply)	5.14 V
16	BRN/RED	Throttle POT wiper (Pedal Position Sensor Input)	4.79 V Full Forward 2.52 V Neutral 0.29 V Full Reverse

Pin	Wire Color	Circuit	Voltage
17		Not Used	
18	VIO/BLK	Throttle POT Low	0.21 V
19		Not Used	
20		Not Used	
21		Not Used	
22		Not Used	
23	YEL	CAN Bus High	2.53 V
24		Not Used	
25	VIO/WHT	Unregulated low power +12 V output. (Power for Serial Port Connector)	12.91 V
26	PINK/RED	Regulated low power +5v output	4.90 V
27		Not Used	
28	WHT/ORN	Serial Transmit for Serial Port Connector	0.18 V
29	BLU/GRN	Serial Receive for Serial Port Connector	0.29 V
30		Not Used	
31	PINK/WHT	Drive Motor Encoder (Speed Sensor) Signal - Phase A	4.06 V or 0.08 V stationary 2.0 V wheel spinning any speed
32	PINK/BLU	Drive Motor Encoder (Speed Sensor) Signal - Phase B	4.06 V or 0.08 V stationary 2.0 V wheel spinning any speed
33		Not Used	
34		Not Used	
35	GRN	CAN Bus Low	2.45 V

Motor U, V and W Terminal Pair Voltages

- U to V - 0.3 - 2.2 VAC with stationary motor. Up to 26 VAC with wheel off ground and full forward speed.
- V to W - 0.3 - 2.2 VAC with stationary motor. Up to 26 VAC with wheel off ground and full forward speed.
- W to U - 0.3 - 2.2 VAC with stationary motor. Up to 26 VAC with wheel off ground and full forward speed.

Motor U, V and W Terminal Pair Frequency

- U to V -21-23 KHZ with stationary motor. Up to 300 KHZ with wheel off ground and full forward speed.
- V to W -21-23 KHZ with stationary motor. Up to 300 KHZ with wheel off ground and full forward speed.
- W to U -21-23 KHZ with stationary motor. Up to 300 KHZ with wheel off ground and full forward speed.

System Current Draw - Driving only with no cleaning functions

Measured with amp clamp around battery positive feed to drive controller.

- Approximately 1-4 amps when the machine begins to move
- Average 51 amps full speed with maximum scrub pressure
- Max - 100 Amps

Wheel Drive Contactor

Winding - 194 Ohms

Special Tools

Curtis Programmer 1311 Part number 56409441